South Indian Education Society's

Graduate School of Technology

NAAC 'A+' , NBA Accredited (EXTC,CE,IT)

Autonomous Institute Affiliated to University of Mumbai

Department of Electronics and Telecommunication

Curriculum Structure for Undergraduate Academic Program in

Electronics and Telecommunication Engineering

Third Year Syllabus

Board of Studies
Department of Electronics and Telecommunication Engineering

Academic Council
SIES Graduate School of Technology

Effective from: AY 2026-27

PREAMBLE

Dear Students, Faculty, and Stakeholders,

Greetings and congratulations to all the stakeholders of SIES Graduate School of Technology for getting autonomous status to the college from the year 2024-25. University Grant Commission vide letter No. F. 2- 10/2023(AC-Policy) dated 10 July 2024 conferred the autonomous status affiliated to University of Mumbai for a period of 10 years from the academic year 2024-2025 to 2033-2034 as per clause 7.5 of the UGC (Conferment of Autonomous Status Upon Colleges and Measures for Maintenance of Standards in Autonomous Colleges) Regulations,2023. Autonomy will help design and implement curriculum which is more learner centric and robust to cater to the changing need of Society and Industry.

The Department of Electronics and Telecommunication SIES Graduate School of Technology, Nerul, Navi Mumbai, was established in 2002 and the current intake capacity is 180.One of the notable achievements is accreditation by the National Board of Accreditation (NBA) in 2011, 2021, 2024 which reflects our commitment in maintaining high standards of education and infrastructure.
We are delighted to announce the introduction of the newly designed curriculum for autonomy at SIES Graduate School of Technology, The newly designed curriculum for the Electronics and Telecommunication course at our autonomous institute is a reflection of our commitment to excellence, innovation, and inclusivity in higher education. Guided by the principles and objectives of the National Education Policy (NEP), this curriculum aims to create a robust framework that not only equips students with in-depth technical knowledge but also fosters holistic development, ethical values, and a lifelong passion for learning.

Curriculum emphases on flexibility, multidisciplinary education, and a learner-centric approach. It aims to develop well-rounded engineers with a strong foundation in core electronics and telecommunication engineering skills, while integrating emerging technologies such as AI, machine learning, and cybersecurity. The curriculum also offers flexibility through electives, allowing students to tailor their education and foster interdisciplinary learning for a comprehensive skill set.

This curriculum is designed with strong industry collaboration to provide students with real-world experience through internships and projects, ensuring they are industry-ready upon graduation. We promote lifelong learning, ensuring that students remain curious, adaptable, and committed to growth throughout their careers. This curriculum empowers students to become innovative engineers, ethical leaders, and global citizens who will contribute to the advancement of technology and the betterment of society.

We would like to express our sincere gratitude to the faculty, alumni, students, industry experts, academicians, and stakeholders for their continuous support in strengthening our academics, making SIESGST one of the top engineering colleges in the nation and the premier choice for engineering aspirants.

Chairperson
Board of Studies
Electronics and Telecommunication Engineering
SIES Graduate School of Technology

HEAD
Department of Electronics & Telecommunications
S.I.E.S. Graduate School of Technology
Sri Chandrasekarendra Saraswathy Vidyapuram
Plot 1-C & E, Sector-V, Nerul, Navi Mumbai-400 706.

Chairperson
Academic Council
SIES Graduate School of Technology

I/c PRINCIPAL
SIES GRADUATE SCHOOL OF TECHNOLOGY (AUTONOMOUS)
Plot 1C/D/E Sri Chandrasekarendra Saraswathy Vidyapuram
Sector V Nerul Navi Mumbai-400706

Semester-wise Credit Distribution Structure for Four Year UG Engineering

Program – Electronics and Telecommunication Engineering

Semester		I	II	III	IV	V	VI	VII	VIII	Total Credits
Basic Science Course(BSC)	BSC/ESC	7	6		--	--	--	--	--	13
Engineering Science Course (ESC)		9	10		--	--	--	--	--	19
Programme Core Course (PCC)	Program Courses	--	--	17	11	12	11	04		55
Programme Elective Course (PEC)		--	--	--	--	03	03	07		13
Multidisciplinary Minor (MDM)	Multidisciplinary Courses		-		03	04	04	04		15
Open Elective(OE) Other than a particular program		--	--	--	--	--	--	03	03	06
Vocational and Skill Enhancement Course (VSEC)	Skill Courses	01	01	02	02	--	02	--	--	08
Ability Enhancement Course (AEC - 01, AEC-02)	Humanities Social Science and Management (HSSM)		02	--	--	02	--	--	--	04
Entrepreneurship/Economics/ Management Courses		--		02	02	--	--	--	--	04
Indian Knowledge System (IKS)			02		--	--	--	--	--	02
Value Education Course (VEC)		--	--	--	02	--	--	--	--	02
Research Methodology(RM)	Experiential Learning Courses	--	--	--	--	--	--	--	03	03
Community Engagement Project (CEP) / Field Project (FP)		--	--	01	01	--	--	-	-	02
Project		--	--	--	--	01	02	02	01	06
Internship/On Job Training (OJT)		--	---						12	12
Co-curricular Courses(CC)	Liberal Learning Courses	04			--	--	--	--	-	04
Total Credits (Major)		**21**	**21**	**22**	**21**	**22**	**22**	**20**	**19**	**168**

CURRICULUM STRUCTURE

AND

THIRD YEAR SYLLABUS

(Electronics and Telecommunication Engineering)

Academic Year 2026-27

Nomenclature of the courses in the curriculum	
Abbreviation	**Title**
BSC	Basic Science Courses
ESC	Engineering Science Courses
PCC	Program Core Courses
PEC	Program Elective Courses
MDM	Multidisciplinary Minor
OE	Open Elective
VEC	Value Education Courses
VSEC	Vocational and Skill Enhancement Courses
AEC	Ability Enhancement Courses
RM	Research Methodology
CEP/FP	Community Engagement Project/Field Project
OJT	On Job Training/Internship
CC	Co-curricular Courses
LLC	Liberal Learning Courses
IKS	Indian Knowledge System
ISE	In Semester Examination
MSE	Mid Semester Examination
ESE	End Semester Examination
CIAP	Continuous Internal Assessment Practical
ESEP	End Semester Examination Practical

SIES Graduate School of Technology
Department of Electronics and Telecommunication Engineering
Bachelor of Engineering

Program Structure for First Year
W.E.F. A.Y. 2024-25
Semester I

Course Code	Course Name	Category	Teaching Scheme (Contact Hours)			Credits Assigned			
			Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
FEC101	Applied Mathematics -I	BSC	3	--	--	3	--	--	3
FEC1021/ FEC1022	Applied Physics/Applied Chemistry@	BSC	3	--	--	3	--	--	3
FEC103	Basic Electrical & Electronics Engineering	ESC	2	--	--	2	--	--	2
FEC104	C-Programming	ESC	2	--	--	2	--	--	2
FEC105	Applied Mechanics and Robot Dynamics	ESC	2	--	--	2	--	--	2
FEL1011	Applied Physics Lab/ Applied Chemistry Lab@	BSC	--	1	--	--	0.5	--	0.5
FEL102	Basic Electrical & Electronics Engineering Lab	ESC	--	2	--	--	1	--	1
FEL103	C-Programming Lab	ESC	--	2	--	--	1	--	1
FEL104	Applied Mechanics and Robot Dynamics Lab	ESC	--	2	--	--	1	--	1
FEL105	Engineering Workshop-I	VSEC	--	2	--	--	1	--	1
FEL106	Health, Wellness and Mindfulness	CC	--	2#+2	--	--	2	--	2
FEL107	Induction Cum Universal Human Values	CC	--	5	--	--	2.5	--	2.5
	Total		**12**	**17**	--	**12**	**9**	--	**21**

Examination Scheme-FY Semester I

Course Code	Course Name	Examination Scheme						
		Theory				CIAP	ESEP	Total
		Internal Assessment		ESE$	Exam Duration (Hrs.)			
		ISE	MSE					
FEC101	Applied Mathematics -I	20	20	60	3	--	--	100
FEC1021/ FEC1022	Applied Physics/ Applied Chemistry@	20	20	60	3	--	--	100
FEC103	Basic Electrical & Electronics Engineering	15	15	45	2	--	--	75
FEC104	C-Programming	15	15	45	2	--	--	75
FEC105	Applied Mechanics and Robot Dynamics	15	15	45	2	--	--	75
FEL1011/ FEL1012	Applied Physics Lab/ Applied Chemistry Lab@	--	--	--	--	25	--	25
FEL102	Basic Electrical & Electronics Engineering Lab	--	--	--	--	25	25	50
FEL103	C-Programming Lab	--	--	--	--	25	25	50
FEL104	Applied Mechanics and Robot Dynamics Lab	--	--	--	--	25	25	50
FEL105	Engineering Workshop-I	--	--	--	--	25	--	25
FEL106	Health, Wellness and Mindfulness	--	--	--	--	25	--	25
FEL107	Induction Cum Universal Human Values	--	--	--	--	25	--	25
	Total	**85**	**85**	**255**	--	**175**	**75**	**675**

@Physics/Chemistry in one semester.
$ ESE of duration 3 hours are of 80 marks and scaled to 60. ESE duration of 2 hours are of 60 marks and scaled to 45.
Theory 1 credit for 1 hour and practical 1 credit for 2 hours.
Two hours of practical class to be conducted for full class as demo/ discussion.
ISE: In Semester Examination:To be conducted in any of these forms - Assignment/ Quiz/ Presentation/ Class Test of 20/15 marks.
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SIES Graduate School of Technology
Department of Electronics and Telecommunication Engineering
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Program Structure for First Year
W.E.F. A.Y. 2024-25

Semester II

Course Code	Course Name	Category	Teaching Scheme (Contact Hours)			Credits Assigned			
			Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
FEC201	Applied Mathematics -II	BSC	3	--	--	3	--	--	3
FEC2021/ FEC1022	Applied Physics/Applied Chemistry@	BSC	3	--	--	3	--	--	3
FEC203	Engineering Graphics	ESC	2	--	--	2	--	--	2
FEC204	Digital System Design	ESC	3	--	--	3	--	--	3
FEC205	Professional Communication Techniques	AEC	2	--	--	2	--	--	2
FEL2011/ FEL1012	Applied Physics Lab/ Applied Chemistry Lab@	BSC	--	1	--	--	0.5	--	0.5
FEL202	Engineering Graphics Lab	ESC	--	2	--	--	1	--	1
FEL203	Digital System Design Lab	ESC	--	2	--	--	1	--	1
FEL204	Professional Communication Techniques Lab	AEC	--	1	--	--	0.5	--	0.5
FEL205	Object Oriented Programming Methodology Lab	ESC	--	2*+2	--	--	2	--	2
FEL206	Engineering Workshop-II	VSEC	--	2	--	--	1	--	1
FEL207	Indian Knowledge System	HSSM	--	2#	--	--	2	--	2
	Total		**13**	**14**	--	**13**	**8**	--	**21**

Examination Scheme-FY Semester II

Course Code	Course Name	Examination Scheme						
		Theory				CIAP	ESEP	Total
		Internal Assessment		ESE$	Exam Duration (Hrs.)			
		ISE	MSE					
FEC201	Applied Mathematics -II	20	20	60	03	--	--	100
FEC2021/ FEC2022	Applied Physics/ Applied Chemistry@	20	20	60	03	--	--	100
FEC203	Engineering Graphics	15	15	45	02	--	--	75
FEC204	Digital System Design	20	20	60	03	--	--	100
FEC205	Professional Communication Techniques	15	15	45	02	--	--	75
FEL2011/ FEL2012	Applied Physics Lab/ Applied Chemistry Lab@	--	--	--	--	25	--	25
FEL202	Engineering Graphics Lab	--	--	--	--	25	25	50
FEL203	Digital System Design Lab	--	--	--	--	25	25	50
FEL204	Professional Communication Techniques Lab	--	--	--	--	25	--	25
FEL205	Object Oriented Programming Methodology Lab	--	--	--	--	25	25	50
FEL206	Engineering Workshop-II	--	--	--	--	25	--	25
FEL207	Indian Knowledge System	--	--	--	--	25	--	25
Total		**90**	**90**	**270**	**--**	**175**	**75**	**700**

@Physics/Chemistry in one semester.
* Two hours of practical class to be conducted for full class as demo/ discussion.
# Course evaluation is an activity based which may be an individual or group of students.
$ ESE of duration 3 hours are of 80 marks and scaled to 60. ESE duration of 2 hours is of 60 marks and scaled to 45.
Theory 1 credit for 1 hour and practical 1 credit for 2 hours.
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SIES Graduate School of Technology
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Program Structure for Second Year
W.E.F. A.Y. 2025-26

Semester III

Course Code	Course Name	Category	Teaching Scheme (Contact Hours)			Credits Assigned			
			Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
ETC301	Applied Mathematics III	PCC	3	--	--	3	--	--	3
ETC302	Electronic Devices and circuits	PCC	3	--	--	3	--	--	3
ETC303	Microprocessor and Microcontroller	PCC	3	--	--	3	--	--	3
ETC304	Network Theory	PCC	3	--	--	3	--	--	3
ETC305	Signals and Systems	PCC	3	--	--	3	--	--	3
ETC306	Engineering Economics	HSSM	2	--	--	2	--	--	2
ETL301	Electronic Devices and circuits Lab	PCC	--	2	--	--	1	--	1
ETL302	Microprocessor and Microcontroller Lab	PCC	--	2	--	--	1	--	1
ETL303	Skill Lab - Python Programming	VSEC	--	2*+2	--	--	2	--	2
ETM301	Mini Project 1A	CEP	--	2#	--	--	1	--	1
Total			**17**	**10**	**--**	**17**	**5**	**--**	**22**

Examination Scheme - EXTC Semester III

Course Code	Course Name	Examination Scheme						
		Theory				CIAP	ESEP	Total
		Internal Assessment		ESE$	Exam Duration (Hrs.)			
		ISE	MSE					
ETC301	Applied Mathematics III	20	20	60	3	--	--	100
ETC302	Electronic Devices and circuits	20	20	60	3	--	--	100
ETC303	Microprocessor and Microcontroller	20	20	60	3	--	--	100
ETC304	Network Theory	20	20	60	3	--	--	100
ETC305	Signals and Systems	20	20	60	3	--	--	100
ETC306	Engineering Economics	50	--	--	--	--	--	50
ETL301	Electronic Devices and circuits Lab	--	--	--	--	25	25	50
ETL302	Microprocessor and Microcontroller Lab	--	--	--	--	25	25	50
ETL303	Skill Lab - Python Programming	--	--	--	--	25	25	50
ETM301	Mini Project 1A	--	--	--	--	25	25	50
Total		**125**	**125**	**300**	**--**	**100**	**100**	**750**

* Two hours of practical class to be conducted for full class as demo/ discussion.
# Indicates workload of a learner (Not faculty) for Mini Project 1A. Faculty Load: ½ hour per week per four groups.
$ ESE of duration 3 hours are of 80 marks and scaled to 60. ESE duration of 2 hours is of 60 marks and scaled to 45.
Theory 1 credit for 1 hour, Tutorial 1 credit for 1 hour and practical 1 credit for 2 hours.
ISE: In Semester Examination**:** To be conducted in any of these forms - Assignment/ Quiz/ Presentation/ Class Test of 20/15 marks.
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SIES Graduate School of Technology
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Program Structure for Second Year
W.E.F.A.Y.2025-26

Semester IV

Course Code	Course Name	Category	Teaching Scheme (Contact Hours)			Credits Assigned			
			Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
ETC401	Applied Mathematics-IV	PCC	3	--	--	3	--	--	3
ETC402	Principles of Communication Engineering	PCC	3		--	3	--	--	3
ETC403	Linear Integrated Circuits	PCC	3		--	3	--	--	3
ETC404	Critical Thinking and Design	HSSM	2	--	--	2	--	--	2
MDMC40X1	Multidisciplinary Minor-I (MDM-I)	MDM	3	--	--	3	--	--	3
ETL401	Principles of Communication Engineering Lab	PCC	--	2	--	--	1	--	1
ETL402	Linear Integrated Circuits Lab	PCC	--	2	--	--	1	--	1
ETL403	Skill Lab - Linux	VSEC	--	2*+2	--	--	2	--	2
ETL404	Value Education (UHV)	HSSM (VEC)	--	4	--	--	2	--	2
ETM401	Mini Project 1B	CEP	--	2#	--	--	1	--	1
Total			**14**	**14**	**--**	**14**	**7**	--	**21**

Examination Scheme - EXTC Semester IV

Course Code	Course Name	Examination Scheme						
		Theory				CIAP	ESEP	Total
		Internal Assessment		ESE$	Exam Duration (Hrs.)			
		ISE	MSE					
ETC401	Applied Mathematics-IV	20	20	60	3	--	--	100
ETC402	Principles of Communication Engineering	20	20	60	3	--	--	100
ETC403	Linear Integrated Circuits	20	20	60	3	--	--	100
ETC404	Critical Thinking and Design	15	15	45	2	--	--	75
MDMC40X1	Multidisciplinary Minor-I (MDM-I)	20	20	60	3	--	--	100
ETL401	Principles of Communication Engineering Lab	--	--	--	--	25	25	50
ETL402	Linear Integrated Circuits Lab	--	--	--	--	25	25	50
ETL403	Skill Lab - Linux	--	--	--	--	25	25	50
ETL404	Value Education (UHV)	--	--	--	--	50	--	50
ETM401	Mini Project 1B	--	--	--	--	25	25	50
Total		**95**	**95**	**285**	--	**150**	**100**	**725**

* Two hours of practical class to be conducted for full class as demo/ discussion.
UHV: Universal Human Values.
# Indicates workload of a learner (Not faculty) for Mini Project 1B. Faculty Load: ½ hour per week per four groups.
$ ESE of duration 3 hours are of 80 marks and scaled to 60. ESE duration of 2 hours is of 60 marks and scaled to 45.
Theory 1 credit for 1 hour, Tutorial 1 credit for 1 hour and practical 1 credit for 2 hours.
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Multidisciplinary Minor - I

Track		
Machine Learning	**Data Science**	**Management**
MDMC4011: Artificial Intelligence	**MDMC4021:** Statistical Foundation for Data Science	**MDMC4061:** Cost Management

Program Structure for Third Year
W.E.F.A.Y.2026-27

Semester V

Course Code	Course Name	Category	Teaching Scheme (Contact Hours)			Credits Assigned			
			Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
ETC501	Digital Communication	PCC	3	--	--	3	--	--	3
ETC502	Computer Communication Networks	PCC	3	--	--	3	--	--	3
ETC503	Electromagnetics Engineering and Antenna	PCC	3	--	--	3	--	--	3
MDMC50X2	Multidisciplinary Minor-II (MDM-II)	MDM	3	--	--	3	--	--	3
ETPEC501X	Program Elective-I	PEC	3	--	--	3	--	--	3
ETL501	Digital Communication Lab	PCC	--	2	--	--	1	--	1
ETL502	Computer Communication Networks Lab	PCC	--	2	--	--	1	--	1
ETL503	Electromagnetics Engineering and Antenna Lab	PCC	--	2	--	--	1	--	1
ETL504	Interpersonal and Career Skills	AEC	--	2*+2	--	--	2	--	2
MDML50X1	Multidisciplinary Minor-II (MDM-II) Lab/Tut[&]	MDM	--	2[&]	--	--	1[&]	--	1
ETM501	Mini Project 2	Project	--	2[#]	--	--	1	--	1
Total			**15**	**14**	--	**14**	**7**	--	**22**

Examination Scheme - EXTC Semester V

Course Code	Course Name	Examination Scheme						
		Theory				CIAP	ESEP	Total
		Internal Assessment		ESE[$]	Exam Duration (Hrs.)			
		ISE	MSE					
ETC501	Digital Communication	20	20	60	3	--	--	100
ETC502	Computer Communication Networks	20	20	60	3	--	--	100
ETC503	Electromagnetics Engineering and Antenna	20	20	60	3	--	--	100
MDMC50X2	Multidisciplinary Minor-II (MDM-II)	20	20	60	3	--	--	100
ETPEC501X	Program Elective-I	20	20	60	3	--	--	100
ETL501	Digital Communication Lab	--	--	--	--	25	25	50
ETL502	Computer Communication Networks Lab	--	--	--	--	25	--	25
ETL503	Electromagnetics Engineering and Antenna Lab	--	--	--	--	25	25	50
ETL504	Interpersonal and Career Skills	--	--	--	--	50	--	50
MDML50X1	Multidisciplinary Minor-II (MDM-II) Lab/ Tut[&]	--	--	--	--	25[&]	--	25
ETM501	Mini Project 2	--	--	--	--	25	25	50
Total		**100**	**100**	**300**	--	**175**	**75**	**750**

* Two hours of practical class to be conducted for full class as demo/ discussion.
# Indicates workload of a learner (Not faculty) for Mini Project 2A. Faculty Load: ½ hour per week per four groups.
$ ESE of duration 3 hours are of 80 marks and scaled to 60. ESE duration of 2 hours is of 60 marks and scaled to 45.
& Tutorials only for management MDM (MDMC5062).
Theory 1 credit for 1 hour, Tutorial 1 credit for 1 hour and practical 1 credit for 2 hours.
ISE: In Semester Examination**:** To be conducted in any of these forms - Assignment/ Quiz/ Presentation/ Class Test of 20/15 marks.
MSE: Mid Semester Examination: To be conducted as written examination for 20/15 marks of duration 1 Hr.
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Program Elective – I

Technology Bucket			
Electronics	**Communication and Networking**	**Security/ Block chain**	**Database Technology**
ETPEC5011: Controls and Sensor Technology	**ETPEC5012:** Internet of Things	**ETPEC5013:** Cryptography and Network Security	**ETPEC5014:** Data Structures and Algorithms

Multidisciplinary Minor - II

Track				
Machine Learning		**Data Science**		**Management**
MDMC5012: Machine Learning	**MDML5011:** Machine Learning Lab	**MDMC5022:** Data Analytics and Visualization	**MDML5021:** Data Analytics and Visualization Lab	**MDMC5062:** Supply Chain Management

SIES Graduate School of Technology
Department of Electronics and Telecommunication Engineering
Bachelor of Engineering

Program Structure for Third Year

W.E.F.A.Y.2026-27

Semester VI

Course Code	Course Name	Category	Teaching Scheme (Contact Hours)			Credits Assigned			
			Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
ETC601	Discrete Signal and Image Processing	PCC	3	--	--	3	--	--	3
ETC602	Mobile Communication Systems	PCC	3	--	--	3	--	--	3
ETC603	Digital VLSI	PCC	3	--	--	3	--	--	3
MDMC60X3	Multidisciplinary Minor-III (MDM-III)	MDM	3	--	--	3	--	--	3
ETPEC601X	Program Elective-II	PEC	3	--	--	3	--	--	3
ETL601	Discrete Signal and Image Processing Lab	PCC	--	2	--	--	1	--	1
ETL602	Mobile Communication and Digital VLSI Lab	PCC	--	2	--	--	1	--	1
ETL603	Skill Lab - Cloud Computing	VSEC	--	2*+2	--	--	2	--	2
MDML60X2	Multidisciplinary Minor-III (MDM-III) Lab/ Tut[&]	MDM	--	2[&]	--	--	1[&]	--	1[&]
ETP601	Major Project I	MJP	--	4[#]	--	--	2	--	2
Total			**15**	**14**	--	**15**	**7**	--	**22**

Examination Scheme - EXTC Semester VI

Course Code	Course Name	Examination Scheme						
		Theory				CIAP	ESEP	Total
		Internal Assessment		ESE[$]	Exam Duration (Hrs.)			
		ISE	MSE					
ETC601	Discrete Signal and Image Processing	20	20	60	3	--	--	100
ETC602	Mobile Communication Systems	20	20	60	3	--	--	100
ETC603	Digital VLSI	20	20	60	3	--	--	100
MDMC60X3	Multidisciplinary Minor-III (MDM-III)	20	20	60	3	--	--	100
ETPEC601X	Program Elective-II	20	20	60	3	--	--	100
ETL601	Discrete Signal and Image Processing Lab	--	--	--	--	25	--	25
ETL602	Mobile Communication and Digital VLSI Lab	--	--	--	--	25	25	50
ETL603	Skill Lab - Cloud Computing	--	--	--	--	25	25	50
MDML60X2	Multidisciplinary Minor-III (MDM-III) Lab/ Tut[&]	--	--	--	--	25[&]	--	25
ETP601	Major Project I	--	--	--	--	25	25	50
Total	--	**100**	**100**	**300**	**--**	**125**	**75**	**700**

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

# Indicates workload of Learner (Not faculty), for Major Project. Project Guide Load = ½ hour per week per project group.

$ ESE of duration 3 hours are of 80 marks and scaled to 60. ESE duration of 2 hours are of 60 marks and scaled to 45.

& Tutorials only for management MDM (MDMC6063).

Theory 1 credit for 1 hour, Tutorial 1 credit for 1 hour and practical 1 credit for 2 hours.

ISE: In Semester Examination:To be conducted in any of these forms - Assignment/ Quiz/ Presentation/ Class Test of 20/15 marks.

MSE: Mid Semester Examination: To be conducted as written examination for 20/15 marks of duration 1 Hr.

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Program Elective – II

Technology Bucket			
Electronics	**Communication and Networking**	**Security/ Block chain**	**Database Technology**
ETPEC6011: Embedded Systems	**ETPEC6012:** Error Control Codes	**ETPEC6013:** IT Infrastructure and Security	**ETPEC6014:** Database Management Systems

Multidisciplinary Minor - III

Track				
Machine Learning		**Data Science**		**Management**
MDMC6013: Natural Language Processing	**MDML6012:** Natural Language Processing Lab	**MDMC6023:** Decision Making and Business Intelligence	**MDML6022:** Decision Making and Business Intelligence Lab	**MDMC6063:** Organizational Behaviour and Human Resource Management

Program Structure for Fourth Year
W.E.F.A.Y.2027-28

Semester VII

Course Code	Course Name	Category	Teaching Scheme (Contact Hours)			Credits Assigned			
			Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
ETC701	Microwave and Radar Engineering	PCC	3	--	--	3	--	--	3
MDMC70X4	Multidisciplinary Minor-IV (MDM-IV)	MDM	3	--	--	3	--	--	3
ETPEC701X	Program Elective-III	PEC	3	--	--	3	--	--	3
ETPEC702X	Program Elective-IV	PEC	3	--	--	3	--	--	3
OEC701X	Open Elective-I	OE	3	--	--	3	--	--	3
ETL701	Microwave and Radar Engineering Lab	PCC	--	2	--	--	1	--	1
MDML70X3	Multidisciplinary Minor-IV (MDM-IV) Lab/ Tut[&]	MDM	--	2[&]	--	--	1[&]	--	1
ETPEL701X	Program Elective-III Lab	PEC	--	2	--	--	1	--	1
ETP701	Major Project II	MJP	--	4[#]	--	--	2	--	2
Total			**15**	**8**	--	**15**	**5**	--	**20**

Examination Scheme - EXTC Semester VII

Course Code	Course Name	Examination Scheme						
		Theory				CIAP	ESEP	Total
		Internal Assessment		ESE[$]	Exam Duration (Hrs.)			
		ISE	MSE					
ETC701	Microwave and Radar Engineering	20	20	60	3	--	--	100
MDMC70X4	Multidisciplinary Minor-IV (MDM-IV)	20	20	60	3	--	--	100
ETPEC701X	Program Elective-III	20	20	60	3	--	--	100
ETPEC702X	Program Elective-IV	20	20	60	3	--	--	100
OEC701X	Open Elective-I	20	20	60	3	--	--	100
ETL701	Microwave and Radar Engineering Lab	--	--	--	--	25	25	50
MDML70X3	Multidisciplinary Minor-IV (MDM-IV) Lab/ Tut[&]	--	--	--	--	25[&]	25[&]	50
ETPEL701X	Program Elective-III Lab	--	--	--	--	25	--	25
ETP701	Major Project II	--	--	--	--	25	25	50
Total		**100**	**100**	**300**	--	**100**	**75**	675

# Indicates workload of Learner (Not faculty), for Major Project. Project Guide Load = ½ hour per week per project group.

$ ESE of duration 3 hours are of 80 marks and scaled to 60. ESE duration of 2 hours is of 60 marks and scaled to 45.

& Tutorials only for management MDM (MDMC7064).

Theory 1 credit for 1 hour, Tutorial 1 credit for 1 hour and practical 1 credit for 2 hours.

ISE: In Semester Examination:To be conducted in any of these forms - Assignment/ Quiz/ Presentation/ Class Test of 20/15 marks.

MSE: Mid Semester Examination: To be conducted as written examination for 20/15 marks of duration 1 Hr.

ESE: End Semester Examination.

CIAP: Continuous Internal Assessment Practical.

ESEP: End Semester Examination Practical.

Program Elective-III

Technology Bucket			
Electronics	**Communication and Networking**	**Security/ Block chain**	**Database Technology**
ETPEC7011: Mixed VLSI	**ETPEC7012:** Wireless Sensor Networks	**ETPEC7013:** Cyber Security and Ethical Hacking	**ETPEC7014:** Advanced Database Management

Program Elective-IV

Technology Bucket			
Electronics	**Communication and Networking**	**Security/ Block chain**	**Database Technology**
ETPEC7021: Robotics	**ETPEC7022:** Satellite and Nano Satellite Communication	**ETPEC7023:** Intelligent Forensics	**ETPEC7024:** Web Technology

Multidisciplinary Minor - III

Track				
Machine Learning		**Data Science**		**Management**
MDMC7014: Deep Learning	**MDML7013:** Deep Learning Lab	**MDMC7024:** Big Data Analytics	**MDML7023:** Big Data Analytics Lab	**MDMC7064:** Marketing Management

Open Elective-I

Course Code	Course Name
OEC7011	Project Management
OEC7012	Finance Management
OEC7013	Management Information System
OEC7014	Entrepreneurship Development and Management
OEC7015	Operation Research
OEC7016	Disaster Management and Mitigation Measures
OEC7017	Product Design

Program Structure for Fourth Year
W.E.F.A.Y.2027-28

Semester VIII

Course Code	Course Name	Category	Teaching Scheme (Contact Hours)			Credits Assigned			
			Theory	Pract.	Tut.	Theory	Pract.	Tut.	Total
ETC801	Research Methodology	RM	3	-	--	3	-	--	3
OEC801X	Open Elective-II	OE	3	--	--	3	--	--	3
ETP801	Major Project III	MJP	--	2#	--	--	1	--	1
ETINT801	Internship/Project/Research	Internship	--	--	--	--	12	--	12
Total			**6**	**2**	--	**6**	**13**	--	**19**

Examination Scheme - EXTC Semester-VIII

Course Code	Course Name	Examination Scheme						
		Theory				CIAP	ESEP	Total
		Internal Assessment		ESE$	Exam Duration (Hrs.)			
		ISE	MSE					
ETC801	Research Methodology	20	20	60	3	--	--	100
OEC801X	Open Elective-II	20	20	60	3	--	--	100
ETP801	Major Project III	--	--	--	--	100	50	150
ETINT801	Internship/Project/Research	--	--	--	--	200	--	200
Total		**40**	**40**	**120**	**--**	**300**	**50**	**550**

# Indicates workload of Learner (Not faculty), for Major Project. Project Guide Load = ½ hour per week per project group.
$ ESE of duration 3 hours are of 80 marks and scaled to 60. ESE duration of 2 hours is of 60 marks and scaled to 45.
Theory 1 credit for 1 hour, Tutorial 1 credit for 1 hour and practical 1 credit for 2 hours.
ISE: In Semester Examination**:** To be conducted in any of these forms - Assignment/ Quiz/ Presentation/ Class Test of 20/15 marks.
MSE: Mid Semester Examination: To be conducted as written examination for 20/15 marks of duration 1 Hr.
ESE: End Semester Examination.
CIAP: Continuous Internal Assessment Practical.
ESEP: End Semester Examination Practical.

Open Elective-II

Course Code	Course Name
OEC8011	Enterprise Resource Planning
OEC8012	Cyber Security and Laws
OEC8013	Energy Audit and Management
OEC8014	IPR and Patenting
OEC8015	Environmental Management
OEC8016	Digital Business Management
OEC8017	Human Resource Management

Multidisciplinary Minor (MDM)

Track	Minor Track	Partner Institute if any	Year/ Sem	Module	Code	Eligible
1	Machine Learning	SIES GST	SE/IV	Artificial Intelligence	MDMC4011	IT/EXTC/ CSE IOT
			TE/V	Machine Learning	MDMC5012	
				Machine Learning Lab	MDML5011	
			TE/VI	Natural Language Processing	MDMC6013	
				Natural Language Processing Lab	MDML6012	
			BE/VII	Deep Learning	MDMC7014	
				Deep Learning lab	MDML7013	
2	Data Science	SIES GST	SE/IV	Statistical Foundation for Data Science	MDMC4021	ECS/CE/EXTC
			TE/V	Data Analytics and Visualization	MDMC5022	
				Data Analytics and Visualization Lab	MDML5021	
			TE/VI	Decision Making and Business Intelligence	MDMC6023	
				Decision Making and Business Intelligence Lab	MDML6022	
			BE/VII	Big Data Analytics	MDMC7024	
				Big Data Analytics Lab	MDML7023	
3	Embedded Systems	SIES GST	SE/IV	Microprocessor and Microcontrollers	MDMC4031	CE/AIDS/AIML
			TE/V	RTOs and Embedded systems	MDMC5032	
				RTOs and Embedded systems Lab	MDML5031	
			TE/VI	Sensor Technology	MDMC6033	
				Sensor Technology Lab	MDML6032	
			BE/VII	Industrial Internet of Things	MDMC7034	
				Industrial Internet of Things Lab	MDML7033	
4	Cyber Security	SIES GST	SE/IV	Computer Network	MDMC4041	AIDS/AIML
			TE/V	Cryptography and Network Security	MDMC5042	
				Cryptography and Network Security Lab	MDML5041	
			TE/VI	Cloud Computing and Security	MDMC6043	
				Cloud Computing and Security Lab	MDML6042	
			BE/VII	Digital Forensics	MDMC7044	
				Digital Forensics Lab	MDML7043	
5	System Programming	SIES GST	SE/IV	Advance Data Structure	MDMC4051	CSEIOT/ECS/ IT
			TE/V	Advance Algorithm	MDMC5052	
				Advance Algorithm Lab	MDML5051	
			TE/VI	System Programming and Compiler Construction	MDMC6053	
				System Programming and Compiler Construction Lab	MDML6052	
			BE/VII	Distributed Systems	MDMC7054	
				Distributed Systems Lab	MDML7053	
6	Management	SIESSBS	SE/IV	Cost Management	MDMC4061	EXTC/CE/IT/ ECS/AIDS/ AIML/CSE IOT
			TE/V	Supply Chain Management	MDMC5062	
			TE/VI	Organizational Behaviour and Human Resource Management	MDMC6063	
			BE/VII	Marketing Management	MDMC7064	

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
ETC501	Digital Communication	03	--	--	03	--	--	03

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE$			
		ISE	MSE				
ETC501	Digital Communication	20	20	60	--	--	100

Course pre-requisite:

1. ETC305: Signals and Systems
2. ETC402: Principles of Communication Engineering

Program Outcomes Addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO5: Modern Tool Usage
4. PO11: Lifelong Learning
5. PSO1: Achieve eminence in domains like signal processing, VLSI, embedded IoT, RF and microwave
6. PSO2: Become technocrats capable of working in multi-disciplinary fields

Course Objectives:

1. To introduce the fundamental concepts, components, and processes involved in a digital communication
2. To develop understanding of information theory and source coding principles for efficient and reliable communication.
3. To analyze and design digital pulse modulation, baseband transmission, and multiplexing techniques used in modern systems.
4. To introduce baseband transmission and detection methods.
5. To compare different digital modulation techniques.
6. To explore and apply digital modulation, demodulation, and spread-spectrum techniques for practical communication applications.

Course Outcomes:

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

1. Analyze the basic model of a digital communication system and distinguish it from analog system.
2. Apply the concepts of information theory in source coding.
3. Analyze and compare PCM, DPCM, DM, and ADM techniques and describe synchronous and asynchronous TDM schemes used in digital carrier systems.
4. Evaluate the performance of baseband transmission systems and apply suitable detection techniques considering inter symbol interference and noise effects.
5. Compare the performances of different digital modulation techniques.
6. Analyze the principles of spread-spectrum communication and assess its applications in secure and interference-resistant digital transmission systems.

Module No.	Unit No.	Topics	Hrs.	CO
1.0		**Introduction to Digital Communication**	**03**	**CO1**
	1.1	Block diagram of a digital communication system, an overview of source coding, channel coding and line coding.		
	1.2	Baseband and passband transmissions with examples.		
		Self-learning: Encryption and decryption, Data compression and expansion.		
2.0		**Information Theory and Source Coding**	**06**	**CO2**
	2.1	Information content of a source symbol, source entropy, average information rate, AWGN channel, Shannon-Hartley channel capacity theorem, Shannon's limit.		
	2.2	Fixed and variable length source codes, statistical and non-statistical source codes, Kraft's inequality, Shannon's source coding theorem, Huffman code, Shannon-Fano code and LZ code.		
		Self-learning: Higher order Huffman code and Shannon-Fano code**,** Demonstrate LZ compression using built-in libraries (zlib in Python).		
3.0		**Digital Pulse Modulation and Digital Multiplexing**	**06**	**CO3**
	3.1	PCM, DPCM, DM, ADM		
	3.2	Digital multiplexing: synchronous and asynchronous, Digital carrier system: European and North American.		
		Self-learning: ADPCM (Adaptive Differential PCM) as a hybrid concept used in G.726 and GSM, Role of PCM and TDM in ISDN, DSL, and optical transmission.		
4.0		**Baseband Transmission and Detection**	**06**	**CO4**
	4.1	Line codes (RZ and NRZ Unipolar formats, RZ and NRZ Polar formats, NRZ Bipolar format (AMI format), NRZ Manchester format, and Quaternary Polar formats). Comparison of line codes with respect to bandwidth, power requirement, synchronization capability, DC level, polarity inversion error and complexity. Power spectral density and spectrum of NRZ Unipolar and Polar formats.		
	4.2	Inter Symbol Interference (ISI), Inter Channel Interference (ICI). Nyquist criterion for distortion less baseband binary transmission, Nyquist bandwidth and practical bandwidth.		
	4.3	Definition of optimum filter and matched filter, optimum detection using integrate and dump receiver.		
		Self-learning: Different line codes used in different communication systems.		
5.0		**Digital Modulation and Demodulation**	**12**	**CO5**
	5.1	Binary ASK, Binary PSK, Quadrature PSK, Off-Set QPSK, M-ary PSK, Binary FSK, M-ary, FSK, 16-ary QASK and MSK. Generation, Detection, Error probability (using signal space representation and Euclidean distance), Bandwidth (using PSD and spectrum except for MSK) and applications of the above modulations.		
		Self-learning: Modulation techniques in modern communication systems.		

6.0		**Spread-spectrum Techniques**	**06**	**CO6**
	6.1	Baseband spread-spectrum system, PN sequence generator, anti-jam capability, DS-BPSK, DS-QPSK and FHSS modulations, Walsh-Hadamard sequence, CDMA.		
		Self-learning: Applications of spread-spectrum in different systems.		
		Total	**39**	

Textbooks:

1. Sklar B, and Ray P. K., *Digital Communication: Fundamentals and applications*, Pearson, Dorling Kindersley (India), Delhi, Second Edition, 2009.
2. T L Singal, *Digital Communication*, Mc-Graw Hill, New Delhi, Third Edition, 2019.
3. P Ramakrishna Rao, *Digital Communication*, Tata Mc-Graw Hill, New Delhi, First Edition,2011.

References:

1. H. Taub, D. Schilling, and G. Saha, *Principles of Communication Systems*, Tata Mc- Graw Hill, New Delhi, Third Edition, 2012.
2. Lathi B P, and Ding Z, *Modern Digital and Analog Communication Systems*, Oxford University Press, Fifth Edition, 2021.
3. Haykin Simon, *Digital Communications*, John Wiley and Sons, New Delhi, Fourth Edition, 2014.

Online Resources:

1. MIT Open Course Ware: Introduction to EECS II: Digital Communication Systems — offered by Massachusetts Institute of Technology (MIT Open Course Ware). Free to access course materials. MIT OpenCourseWare
2. NPTEL: Principles of Communication Systems: Part II — offered via Indian Institute of Technology Kanpur/National Programme on Technology Enhanced Learning (NPTEL). Covers digital communication systems including modulation, information theory. NPTEL
3. Coursera: Digital Communication and Emotion — via Arizona State University on Coursera; useful for the communication aspects in digital age. Coursera
4. Graduate Certificate in Digital Communication — a formal certificate programme (online) offered by University of Alabama (UA Online). Online and Distance Degrees - UA Online

Course Assessment:

ISE:

- To be conducted in any of these forms - Assignment/ Quiz/ Presentation/ Class Test/ Case study etc. of 20 marks
- ISE 20 marks= 05 marks for attendance + 15 marks for activities.

MSE:

- To be conducted as written examination for 20 marks (on 40% - 50% syllabus)

End Semester Examination:

$ ESE of duration 03 hours is 80 marks and scaled to 60.

1. The question paper will comprise 03 questions.
2. Question1 (20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
3. Question 2 (40 marks): - Solve any 04 out of 06. All questions carry 10 marks each.
4. Question 3 (20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
5. All COs should be mapped as per the weightage in the syllabus.

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
ETC502	Computer Communication Networks	03	--	--	03	--	--	03

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE$			
		ISE	MSE				
ETC502	Computer Communication Networks	20	20	60	--	--	100

Course pre-requisite:

1. ETC402: Principles of Communication Engineering

Program Outcomes Addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Modern Tool usage
4. PO11: Lifelong Learning
5. PSO1: Achieve eminence in domains like signal processing, VLSI, embedded IoT, RF and microwave
6. PSO2: Become technocrats capable of working in multi-disciplinary fields.

Course Objectives:

1. To introduce the fundamental concepts of computer networks, including architectures, protocol layers, and service models.
2. To explain the principles and functions of the Physical, Data Link, and Network layers, including data transmission, framing, switching, addressing, and routing.
3. To apply intra-network communication with data link layer.
4. To introduce network addressing and routing.
5. To analyze the mechanisms of the Transport layer such as reliability, flow control, congestion control, and differentiate between TCP and UDP protocols.
6. To explore Application layer protocols and develop the ability to analyze basic networked communication systems.

Course Outcomes:

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

1. Describe the fundamental network architectures, the OSI/TCP-IP layered models, and the role of protocols in enabling communication.
2. Analyze data transmission principles, media characteristics, and performance metrics of the Physical layer.
3. Apply data link mechanisms such as framing, error control, flow control, and evaluate MAC protocols and LAN technologies.
4. Compute and evaluate IP addressing, sub-netting, packet forwarding, and routing protocols used for end-to-end delivery.
5. Compare and analyze transport-layer services including reliability, congestion control, and the

differences between TCP and UDP.

6. Apply common application-layer protocols (HTTP, DNS, SMTP, etc.) to understand how networked applications operate over the Internet.

Module No.	Unit No.	Topics	Hrs.	CO
1.0		**Introduction to Network Architectures, Protocol Layers, and Service Models**	**04**	**CO1**
	1.1	Applications of computer networks. Network types: LAN, MAN, and WAN, Network and line topologies.		
	1.2	Protocols and standards, need of layered protocol architecture, OSI reference model		
	1.3	TCP/IP architecture: protocol suite, comparison of OSI and TCP/IP		
	1.4	Layer wise network hardware devices (NIC, Repeaters, Hubs, Bridges, Switches, Routers, Gateway and their comparison)		
	1.5	Addressing: physical / logical /port addressing/socket addressing.		
		Self-learning: Role of modulation and demodulation, Compare a digital vs. analog communication system.		
2.0		**Physical Layer**	**03**	**CO2**
	2.1	Guided transmission media: comparison among coaxial, optical fiber and twisted pair cables.		
	2.2	Unguided transmission media: Cellular, microwave, infrared, Bluetooth		
	2.3	Broadband standards: Cable modem, xDSL, and HFC		
		Self-learning: Interface standards for Wi-Fi, Bluetooth and IoT		
3.0		**Data Link Layer**	**06**	**CO3**
	3.1	Data link services: Framing, Flow control, Error control, Piggybacking		
	3.2	High Level Data Link Control (HDLC): HDLC configurations, Frame formats, HDLC bit stuffing and de-stuffing, Typical frame exchanges, Ethernet standards, VLAN, Spanning Tree Protocol, Point to Point Protocol		
	3.3	Medium Access Control Protocols: Aloha, Slotted Aloha, CSMA, CSMA/CD		
		Self-learning: SDLC, Character stuffing		
4.0		**Network Layer**	**14**	**CO4**
	4.1	Introduction to switching techniques: circuit switching, packet switching, connection-oriented, and connectionless services.		
	4.2	Internet Protocol: Principles of Internetworking, requirements, IPv4 packet, IPv4 addressing (classful and classless (CIDR))		
	4.3	Routing in Packet Switching Networks: Characteristics, Routing strategies, Routing algorithms: Link state Routing, Distance vector Routing, Bellman- Ford and Dijkstra's algorithm, Routing protocols: RIP, OSPF, BGP and EIGRP.		
	4.4	Sub-netting, super netting, VLSM, and NAT		
	4.5	Introduction to ICMP, ARP, RARP, MPLS and GMPLS.		
	4.6	IPv6 (IPv6 Datagram format, comparison with IPv4, and transition from IPv4 to IPv6).		
		Self-learning: Multicasting and broadcasting protocols		

5.0		**Transport Layer**	**06**	**CO5**
	5.1	Connectionless and connection–oriented services at transport layer, Transmission Control Protocol (TCP): TCP Services, TCP Segment, TCP three-way handshake.		
	5.2	User datagram Protocol (UDP), UDP Services, UDP Datagram		
	5.3	Flow control, error control and congestion control		
		Self-learning: TCP Timers, Options, SCTP		
6.0		**Application Layer**	**06**	**CO6**
	6.1	Introduction to session, presentation and application layer protocols: SSL, TSL, HTTP, FTP, DNS, SMTP, TELNET, SSH, DHCP.		
		Self-learning: Multimedia and network security.		
		Total	**39**	

Textbooks:

1. Behrouz A. Forouzan, *Data Communications and Networking*, Fifth Edition, TMH, 2017.
2. Andrew S Tanenbaum, *Computer Networks*, 5th Edition, Pearson Education, 2013.
3. J. J. F. Kurose and K. W. Ross, *Computer Networking: A Top-Down Approach*, Addison Wesley,8th Edition, 2022.

References:

1. Alberto Leon Garcia, *Communication Networks, McGraw Hill Education*, Second Edition, Fourth Edition, 2008.
2. S. Keshav, *An Engineering Approach to Computer Networks*, 2nd Edition, Pearson Education, 2015.
3. W.A. Shay *Understanding communications and Networks,* 3rd Edition, Cengage Learning, 2003.
4. William Stallings, *Data and Computer Communications*, 10th Edition, Pearson Education, 2014.

Online Resources:

1. NPTEL: Computer Networks by Dr. Karthik N, NIT, Puducherry NPTEL Swayam - NPTEL
2. NPTEL: Advanced Computer Networks by Prof. Neminath Hubballi and Prof. Sameer G Kulkarni, IIT Indore / IIT Gandhinagar NPTEL Swayam - NPTEL

Course Assessment:

ISE:

- To be conducted in any of these forms - Assignment/ Quiz/ Presentation/ Class Test/ Case study etc. of 20 marks
- ISE 20 marks= 05 marks for attendance + 15 marks for activities.

MSE:

- To be conducted as written examination for 20 marks (on 40% - 50% syllabus)

End Semester Examination:

$ ESE of duration 03 hours is 80 marks and scaled to 60.

1. The question paper will comprise 03 questions.
2. Question1 (20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
3. Question 2 (40 marks): - Solve any 04 out of 06. All questions carry 10 marks each.
4. Question 3 (20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
5. All COs should be mapped as per the weightage in the syllabus.

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
ETC503	**Electromagnetics Engineering and Antenna**	**03**	--	--	03	--	--	**03**

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE$			
		ISE	MSE				
ETC503	**Electromagnetics Engineering and Antenna**	**20**	**20**	60	--	--	100

Course pre-requisite:

1. FEC201: Applied Mathematics-II
2. ETC402: Principles of Communication Engineering

Program Outcomes Addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/Development of solutions
4. PO5: Engineering tool usage
5. PO11: Lifelong learning
6. PSO1: Achieve eminence in domains like signal processing, VLSI, embedded IoT, RF and microwave

Course Objectives:

1. To explain the fundamental concepts of electrostatics and magnetostatics including field laws and equations.
2. To interpret Maxwell's equations and electromagnetic wave propagation in different media.
3. To explain antenna fundamentals, radiation mechanisms, and key antenna parameters.
4. To understand and analyze the principles of antenna arrays and pattern formation.
5. To explore various practical antennas and their design considerations.
6. To understand different modes of radio wave propagation.

Course Outcomes:

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

1. Explain and apply Coulomb's law, Gauss's law, Biot–Savart law, and Ampere's law to analyze static electric and magnetic fields and solve related problems.
2. Interpret Maxwell's equations and analyze EM wave propagation in lossy, dielectric, and conducting media, including power flow using Poynting theorem.
3. Describe antenna radiation mechanisms, parameters, and analyze basic wire antennas such as dipole and loop antennas.
4. Analyze linear antenna arrays and apply the principle of pattern multiplication to determine radiation

patterns.

5. Describe and compare different antennas such as Yagi–Uda, helical, horn, reflector, and microstrip patch antennas.
6. Differentiate between ground wave, sky wave, and space wave propagation mechanisms and their applications.

Module No.	Unit No.	Topics	Hrs.	CO
1.0		**Introduction to Static Fields**	**06**	**CO1**
	1.1	Coulomb's law, electric field intensity, electric flux density, Gauss's law and applications, current density, and continuity equation.		
	1.2	Laplace's and Poison's equations.		
	1.3	Biot Savart law, ampere circuit law, Gauss's law for magnetic field, vector magnetic potential.		
		Self-learning: Coordinate systems, scalar electric potential, potential gradient, charge and charge configurations.		
2.0		**Electromagnetic Field and Maxwell's Equations**	**09**	**CO2**
	2.1	Displacement current density, Maxwell's equation for time varying field, boundary conditions.		
	2.2	EM wave propagation through lossy, perfect dielectric and conducting medium.		
	2.3	Power in EM wave: Poynting theorem and pointing vector.		
		Self-learning: Faraday's law.		
3.0		**Basics of Antennas**	**08**	**CO3**
	3.1	Basic concepts: Radiation mechanism, near field and far field radiations, Retarded potential.		
	3.2	Antenna Parameters: Isotropic antenna, radiation pattern, radiation intensity, beamwidth, directivity, gain, beam efficiency, bandwidth, polarization, input impedance, antenna efficiency, radiation resistance, loss resistance, aperture concept, FRII's transmission formula.		
		Wire Elements: Infinitesimal dipole, wire dipole: radiation field derivations and related parameters, introduction to loop antenna.		
		Self-learning: Monopole antennas.		
4.0		**Antenna Arrays**	**06**	**CO4**
	4.1	Linear arrays of two isotropic point sources, linear arrays of N elements, and principle of pattern multiplication.		
	4.2	Planar and circular arrays.		
		Self-learning: Binomial array.		
5.0		**Types of Antennas**	**06**	**CO5**
	5.1	Yagi antenna, broadband antenna like helical and log periodic antenna Horn Antennas**:** E-plane sectoral horn, H-plane sectoral horn.		
	5.2	Reflector Antennas: Parabolic reflector.		
	5.3	Patch Antenna: Microstrip antenna, feeding techniques, introduction to design of microstrip antenna (Rectangular and circular patch)		
		Self-learning: Conical and pyramidal horn		

6.0		**Electromagnetic Wave Propagation**	**04**	**CO6**
	6.1	Ground wave propagation, sky wave propagation and space wave propagation.		
		Self-learning: Duct propagation.		
		Total	**39**	

Textbooks:

1. Jordan and Balmain, *Electromagnetic Waves and Radiating Systems*, PHI, 2nd edition, 1968.
2. Matthew N. O.Sadik , S.V.Kulkarni, *Principles of Electromagnetics Engineering*, Oxford University Press, 6th edition, 2015.
3. Costantine A. Balanis, *Antenna Theory: Analysis and Design,* John Wiley Publication, 4th Edition, 2016.
4. John D Kraus, A S Khan, *Antenna and Wave Propagation*, McGraw Hill, 4th edition, 2010.
5. Stutzman, Theile, *Antenna Theory and Design*, John Wiley and Sons, 3rd edition, 2012.

References:

1. William H Hayt and John A Buck, *Engineering Electromagnetics*, Tata McGraw-Hill Publishing Company Limited, 9th edition, 2018.
2. R. E. Collin, *Antennas and Radio Wave Propagation*, McGraw Hill, International Student edition, 1985.

Online Resources:

1. Coursera: Antenna Design and Analysis by top universities https://www.coursera.org/learn/microwave-antenna
2. edX: Electromagnetic Waves and Antennas by MIT https://ocw.mit.edu/courses/6-013-electromagnetics-and-applications-spring-2009/
3. Udemy: Practical Antenna Design: From Theory to Simulation https://www.udemy.com/course/antennas-fundamental-parameters-theory-and-design
4. NPTEL: Antennas by Prof. Girish Kumar, IIT Bombay Swayam - NPTEL
5. NPTEL: Analysis and Design Principles of Microwave Antennas by Prof. Amitabha Bhattacharya, IIT Kharagpur https://onlinecourses.nptel.ac.in/

Course Assessment:

ISE:

- To be conducted in any of these forms - Assignment/ Quiz/ Presentation/ Class Test/ Case study etc. of 20 marks
- ISE 20 marks= 05 marks for attendance + 15 marks for activities.

MSE:

- To be conducted as written examination for 20 marks (on 40% - 50% syllabus)

End Semester Examination:

$ ESE of duration 03 hours are of 80 marks and scaled to 60.

1. The question paper will comprise 03 questions.
2. Question1 (20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
3. Question 2 (40 marks): - Solve any 04 out of 06. All questions carry 10 marks each.
4. Question 3 (20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
5. All COs should be mapped as per the weightage in the syllabus.

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
MDMC5012	Machine Learning	3	--	--	3	--	--	3

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE$			
		ISE	MSE				
MDMC5012	Machine Learning	20	20	60	--	--	100

Course pre-requisite:

1. MDMC4011: Artificial Intelligence

Program Outcomes Addressed

1. PO1: Engineering Knowledge
2. PO2: Problem Analysis
3. PO3: Design/Development of solutions
4. PO4: Conduct investigation of complex problem
5. PO7: Ethics

Course Objectives:

1. To introduce Machine learning concepts.
2. To explain various supervised Machine Learning Techniques.
3. To describe various unsupervised Machine Learning Techniques
4. To highlight the importance of Dimensionality Reduction and apply it in ML.
5. To introduce the foundational concepts, architectures, and learning mechanisms of Artificial Neural Networks and developing basic neural network–based learning models
6. To provide students with a comprehensive understanding of ensemble learning techniques.

Course Outcomes:

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

1. Explain the basics of Machine Learning
2. Apply various supervised Machine Learning Techniques.
3. Apply various unsupervised Machine Learning Techniques.
4. Apply Dimensionality Reduction techniques.
5. Evaluate ensemble learning techniques to real world problems.
6. Analyze the perceptron model, including its learning rules, capabilities, and limitations for linearly separable problems.

Module No.	Unit No.	Topics	Hrs.	CO
1.0		**Machine Learning Basics**	**06**	**CO1**
	1.1	Introduction to Machine learning, Key Terminologies, Types of ML: Supervised learning, Unsupervised learning, Reinforcement learning Applications of ML, Steps in developing ML applications, Issues in Machine Learning, overfitting and underfitting of model.		
	1.2	Introduction to Data Preprocessing, Data Collection, Data Cleaning, Data splitting for training, validation and Test		
		Self-learning: Advanced Data Preprocessing Techniques		
2.0		**Supervise Learning**	**08**	**CO2**
	2.1	Linear Regression, Multiple Linear Regression, Logistic Regression.		
	2.2	Decision Tree classification: ID3, KNN, SVM., Basics of Kernel trick.		
	2.3	Performance measures classification: Confusion Matrix, Accuracy, Precision, Recall, Performance measures regression: MSE, RMSE, MAE		
		Self-learning: CART		
3.0		**Unsupervised Learning**	**07**	**CO3**
	3.1	Introduction, Supervised vs Unsupervised Learning, Advantages and disadvantages of Unsupervised learning, Application, Challenges		
	3.2	Clustering: types. Algorithms: K-means, K-medoid, Agglomerative (Single linkage, complete linkage, average linkage, centroid based), Divisive, DBSCAN.		
		Self-learning: Association rule Learning: Apriori Algorithm. Real world use cases of unsupervised learning: Healthcare, finance		
4.0		**Dimensionality Reduction**	**04**	**CO4**
	4.1	Introduction to Dimensionality Reduction, Curse of Dimensionality.		
	4.2	Feature Selection (FS): Filter, Wrapper, Embedded approaches.		
	4.3	Feature Extraction (FE): Principal Component Analysis (PCA). FS vs FE.		
		Self-learning: Autoencoders for Dimensionality Reduction/ PCA vs Autoencoders.		
5.0		**Ensemble Learning**	**08**	**CO5**
	5.1	Introduction, Why Ensemble Methods? Basic Ensemble Techniques: Averaging methods, Voting methods		
	5.2	Types of Ensemble Techniques: Bagging, Boosting, Stacking, Blending.		
	5.3	Bagging Methods: Random Forest. Boosting Methods: AdaBoost, XGBoost.		
		Self-learning: Out-of-Bag (OOB) Error Estimation		
6.0		**Introduction to Artificial Neural Networks**	**06**	**CO6**
	6.1	Introduction to Artificial Neural Networks, basic concepts, evolution of neural networks, biological neuron vs artificial neuron, McCulloch–Pitts model, ANN architecture, bias, weights and activation functions (binary, bipolar, sigmoid, Tanh, ReLU), perceptron model, linearly separable and non-separable patterns, and limitations of the perceptron.		
	6.2	Perceptron Learning Rule, Delta Learning Rule (LMS / Widrow–Hoff), introduction to multilayer perceptron (MLP), forward propagation, Gradient Descent, the backpropagation algorithm.		
		Self-learning: Basic applications of ANN in classification and regression tasks.		
		Total	**39**	

Textbooks:

1. P. Harrington, *Machine Learning in Action*, 1st ed. New Delhi, India: DreamTech Press, 2012.
2. N. Japkowicz and M. Shah, *Evaluating Learning Algorithms*, 1st ed. Cambridge, U.K.: Cambridge University Press, 2011.
3. E. Alpaydın, *Introduction to Machine Learning*, 4th ed. Cambridge, MA, USA: MIT Press, 2020.
4. P. Flach, *Machine Learning*, 2nd ed. Cambridge, U.K.: Cambridge University Press, 2022.
5. T. M. Mitchell, *Machine Learning*, 2nd ed. New York, NY, USA: McGraw-Hill, 1997.
6. Z.-H. Zhou, *Ensemble Methods: Foundations and Algorithms*, 1st ed. Boca Raton, FL, USA: CRC Press, 2012.

Reference books:

1. J. Han, M. Kamber, and J. Pei, *Data Mining: Concepts and Techniques*, 4th ed. San Francisco, CA, USA: Morgan Kaufmann, 2022.
2. M. H. Dunham, *Data Mining: Introductory and Advanced Topics*, 1st ed. Upper Saddle River, NJ, USA: Pearson, 2006.
3. K. P. Murphy, *Machine Learning: A Probabilistic Perspective*, 1st ed. Cambridge, MA, USA: MIT Press, 2012.
4. S. Roy and U. Chakraborty, *Introduction to Soft Computing*. Noida, India: Pearson, 2024.
5. R. O. Duda, P. E. Hart, and D. G. Stork, *Pattern Classification*, 2nd ed. New York, NY, USA: Wiley, 2000.

Online References:

1. Kaggle: Data sets for Machine Learning algorithms - https://www.kaggle.com/datasets
2. UCI Machine Learning Repository: Machine Learning repository - https://archive.ics.uci.edu/ml/index.php
3. Machine Learning from Coursera - https://www.coursera.org/collections/machine-learning https://towardsdatascience.com/machine-learning/home
4. NPTEL course -Introduction to Machine Learning – IITKGP, Prof. Sudeshna Sarkar - https://onlinecourses.nptel.ac.in/noc21_cs85/preview

Course Assessment:

ISE:

- To be conducted in any of these forms - Assignment/ Quiz/ Presentation/ Class Test/ Case study etc. of 20 marks.
- ISE 20 marks = 05 marks for attendance + 15 marks for activities.

MSE:

- To be conducted as written examination for 20 marks (on 40% - 50% syllabus)

End Semester Examination:

$ ESE of duration 03 hours are of 80 marks and scaled to 60.

1. Question paper will comprise of 03 questions.
2. Question1(20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
3. Question 2 (40 marks): - Solve any 04 out of 06. All questions carry 10 marks each.
4. Question 3(20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
5. All COs should be mapped as per the weightage in the syllabus.

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
MDMC5022	Data Analytics and Visualization	03	--	--	03	--	--	03

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE$			
		ISE	MSE				
MDMC5022	Data Analytics and Visualization	20	20	60	--	--	100

Course pre-requisite:

1. ETC301: Applied Mathematics III
2. ETL303: Skill Lab - Python Programming
3. ETC401: Applied Mathematics IV

Program Outcomes Addressed:

1. PO1: Engineering Knowledge:
2. PO2: Problem Analysis
3. PO4: Conduct Investigations of Complex Problems
4. PO5: Engineering Tool Usage
5. PO11: Lifelong Learning

Course Objectives:

1. To introduce the concept of Data Analytics Lifecycle.
2. To develop data modeling using Regression and Time series Techniques.
3. To define geospatial data and geospatial information.
4. To create awareness about Text analytics and its applications.
5. To provide overview of Data analytics and visualization with R/ Python.
6. To understand data visualization using visualization tools.

Course Outcomes:

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

7. Apply the data analytics lifecycle to prepare data and build analytical models.
8. Apply Regression and Timeseries models on a given data set and perform prediction.
9. Illustrate various types of sources for raster and vector data.
10. Analyze Text data and gain insights.
11. Experiment with different analytics techniques and visualization using R / Python
12. Develop interactive dashboards integrating data transformation and visualization for professional reporting.

Module No.	Unit No.	Topics	Hrs.	CO
1.0		**Introduction to Data analytics and Life cycle**	**04**	**CO1**
	1.1	**Data Analytics Lifecycle Overview:** Key roles, project background, business understanding, hypothesis creation, and identification of data sources.		
	1.2	**Data Preparation and Modeling:** Data conditioning, Extract–Transform–Load (ETLT), exploration, visualization, variable selection, and model planning/building using common analytical tools.		
	1.3	**Results and Deployment:** Communicating insights effectively and operationalizing the analytics solution for real-world implementation.		
		Self-learning: Case studies of end-to-end analytics projects, CRISP-DM vs Data Analytics Lifecycle		
2.0		**Regression Models and Time Series**	**08**	**CO2**
	2.1	**Regression:** Regression equation, **assessing** model fit and assumptions, Cross-validation and model selection, Stepwise regression methods, Prediction using regression models.		
	2.2	**Logistic Regression and Comparison:** Logistic Response function and logit, Logistic regression and Generalized Linear model, ROC, AUC, and confusion matrix for model evaluation Linear and logistic regression: similarities and differences.		
	2.3	Overview of Time Series Analysis Box-Jenkins Methodology, ARIMA Model Autocorrelation Function (ACF), Autoregressive Models, Moving Average Models, ARMA and ARIMA Models, Building and Evaluating an ARIMA Model, Reasons to Choose and Cautions		
		Self-learning: Introduction to GLM families beyond logistic (Poisson, Gamma), GARCH models for volatility forecasting (finance)		
3.0		**Geospatial Data Analysis**	**08**	**CO3**
	3.1	Introduction to Geospatial Data, Sources of Raster Data, Sources of Vector Data, Overview of Geospatial Data Analysis Tools, Overview of Geospatial Programming languages.		
		Self-learning: Case studies of applications where raster and vector data is used.		
4.0		**Text Analytics**	**06**	**CO4**
	4.1	History of text mining, Roots of text mining overview of seven practices of text analytic, Application and use cases for Text mining: extracting meaning from unstructured text, Summarizing Text.		
	4.2	Text Analysis Steps, A Text Analysis Example, Collecting Raw Text, Representing Text, Term Frequency—Inverse Document Frequency		
		(TFIDF), Categorizing Documents by Topics, Determining Sentiments, Gaining Insights.		
		Self-learning: Case studies on healthcare (clinical notes), Ecommerce (reviews, rating analysis)		

5.0		**Data Analytics and visualization with R / Python**	**06**	**CO5**
	5.1	Introduction to R: Data Import and Export, Attribute and Data type, Descriptive statistics, Visualization and Analysis using R.		
	5.2	Essential Data Libraries for data analytics and Visualization in Python, Visualization and Analysis using Python.		
		Self-learning: Case studies on simple analytical reports using Python or R, Introduction to dataset import workflows in R/Python		
6.0		**Introduction to Data Visualization Tools**	**07**	**CO6**
	6.1	Tool interfaces, data connections, data cleaning and modeling, building interactive dashboards with filters, slicers, and publishing reports. Principles of effective data visualization, chart selection, and visual design.		
	6.2	Basics of DAX, calculated columns, measures, and essential time-intelligence functions.		
	6.3	Storytelling with data for business insights and ethical visualization practices. Interactive reporting with filters, bookmarks, and performance optimization.		
		Self-learning: Introduction to connecting different data sources in dashboards		
		Total	**39**	

Textbooks:

1. D. Dietrich, *Data science and big data analytics : discovering, analyzing, visualizing and presenting data*. Indianapolis, IN: Wiley, 2015.
2. B. Motwani, *Data Analytics Using Python*. New Delhi, India: Wiley Publications, 2019.
3. B. Motwani, *Data Analytics Using R*. New Delhi, India: Wiley Publication, 2015.
4. P. Bruce, A. Bruce, and P. Gedeck, *Practical Statistics for Data Scientists: 50+ Essential Concepts Using R and Python*, 2nd ed., Sebastopol, CA, USA: O'Reilly Media, 2020.
5. G. Miner and T. Hill, *Practical Text Mining and Statistical Analysis for Non-Structured Text Data Applications*, 1st ed., Burlington, MA, USA: Academic Press, 2012.

Reference books:

1. J. Han, M. Kamber, and J. Pei, *Data Mining: Concepts and Techniques*, 3rd ed., Waltham, MA, USA: Morgan Kaufmann, 2011.
2. W. McKinney, *Python for Data Analysis: Data Wrangling with pandas, NumPy, and Jupyter*, 3rd ed., Sebastopol, CA, USA: O'Reilly Media, 2022.

Online References:

1. NPTEL: Introduction to Data Analytics: https://nptel.ac.in/courses/110106072
2. Coursera: Data Visualization with Python: Data Visualization with Python | Coursera

Course Assessment:

ISE:

- To be conducted in any of these forms - Assignment/ Quiz/ Presentation/ Class Test/ Case study etc. of 20 marks.
- ISE 20 marks = 05 marks for attendance + 15 marks for activities.

MSE:

- To be conducted as written examination for 20 marks (on 40% - 50% syllabus)

End Semester Examination:

$ ESE of duration 03 hours are of 80 marks and scaled to 60.

1. Question paper will comprise of 03 questions.
2. Question1(20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
3. Question 2 (40 marks): - Solve any 04 out of 06. All questions carry 10 marks each.
4. Question3(20 marks):- Solve any 04 out of 06. All questions carry 05 marks each.
5. All COs should be mapped as per the weightage in the syllabus.

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
MDMC5062	Supply Chain Management	03	--	01	03	--	01	04

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE$			
		ISE	MSE				
MDMC5062	Supply Chain Management	20	20	60	25	--	125

Course pre-requisite:

1. Basic MS Excel.

Program Outcomes Addressed

1. PO1: Engineering Knowledge
2. PO2: Problem Analysis
3. PO7: Global and Ethical Practices
4. PO8: Collaborative Teamwork
5. PO9: Communication
6. PO11: Lifelong Learning

Course Objectives:

1. To introduce the fundamental concepts, components, and processes of supply chain management in manufacturing and service sectors.
2. To develop understanding of demand forecasting, inventory management, procurement, and logistics as core elements of SCM.
3. To equip students with the ability to analyze supply chain networks, evaluate performance, and identify improvement opportunities.
4. To familiarize students with supply chain technologies such as ERP systems, RFID, IoT, and analytics tools.
5. To build decision-making skills related to sourcing, production planning, transportation, and distribution strategies.
6. To promote awareness of sustainability, risk management, and global challenges in supply chain operations.

Course Outcomes:

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

1. To explain key supply chain, logistics, and international shipping concepts.
2. To apply analytical tools to solve basic warehousing, transportation, and network design problems.
3. To analyze supply chain flows and identify performance gaps, risks, and integration challenges.
4. To evaluate supply chain efficiency using cost, service, sustainability, and responsiveness metrics.
5. To design technology-enabled and resilient supply chain solutions for domestic and global environments.
6. To demonstrate understanding of sustainable, ethical, and technology-enabled supply chain practices and assess their impact on organizational performance.

Module No.	Unit No.	Topics	Hrs.	CO
1.0		**Module 1: Introduction to Supply Chain, Logistics and International Shipping**	**09**	**CO1, CO2**
	1.1	Introduction to Supply Chain, Decision Phases in a Supply Chain, Linkages and Decisions in SCM. Process and Cycle View of a Supply Chain. Supply Chain Models: Efficient Chain, Responsive Supply Chain and Agile Models. Importance of supply chain flows. Logistics and Shipping: functions. Objectives, Goals, Decisions. 1st Party, 2nd Party, 3rd Party, 4th Party Logistic service provider Introduction to International Shipping: Freight Forwarders, shipping documents, Ports and customs, Incoterms Reverse Logistics.		
		Self-learning: Importance of supply chain flows. Logistics and Shipping: functions. Objectives, Goals, Decisions		
2.0		**Warehousing and Transportation**	**09**	**CO2, CO3**
	2.1	Warehouse: role, type, functions. Warehouse location modelling: methods such as COG, MCOG, and the LP approach. Layout design, Space calculation, Warehouse automation, Hub and Spoke Model, WMS Distribution, Role, Importance, Levels, Channels, Structure, Functions. Channel partners, functions. Infrastructure, road, rail, air, water, pipeline. Freight Management, Freight cost. Transportation Network Route Planning, Containerization, and Packing. Effective / Cost Optimising strategies. Cross-docking, Milk run, and transhipment.		
		Self-learning: Role, Importance, Levels, Channels, Structure, Functions. Channel partners, functions.		
3.0		**Performance Measurement and Controls in Supply Chain Management**	**03**	**CO3, CO4**
	3.1	Supply Chain Cost Calculations Supply Chain Reliability and Responsiveness Supply Chain Asset Management: cash to cash cycle, return on working capital and working capital Analytics Framework Based on SCOR Model		
		Self-learning: Concepts of Supply Chain Asset Management: cash to cash cycle and working capital		

4.0		**Designing a network in a supply chain**	**06**	**CO2, CO4, CO5**
	4.1	Network design in the supply chain Alternate channels in distribution Location decisions in the supply chain using Excel Role and factors affecting network designing Network Optimisation Model Network design in an uncertain environment Flexibility in Supply Chain Practical problems using Excel		
		Self-learning: Role and factors affecting network designing		
5.0		**Supply Chain Integration and Designing Global Supply Chain Networks**	**06**	**CO3, CO5**
	5.1	Bullwhip effect, Collaborative Planning Forecasting Replenishment (CPRF) concept. Inventory Management and Risk Pooling, Strategic Alliances, Retailer-Supplier Partnerships: Types, Requirements, and Inventory Ownership. Outsourcing and related decisions Global Market: Technological/ Cost/ Political, and Economic Forces. Risks and Advantages of the International Supply Chain. International versus Regional products. Local autonomy versus central control. Regional differences in Logistics- Cultural differences/ infrastructure/ performance expectation, and evaluation, Information systems availability, and human resources.		
		Self-learning: Concepts related to Outsourcing and related decisions, Risks and Advantages of the International Supply Chain.		
6.0		**Ethical issues in Supply Chain and Technological Trends in Supply Chain**	**06**	**CO4, CO5**
	6.1	Supply chain vulnerability. Conformance to applicable laws such as Contract and commercial laws, Trade regulation, government procurement regulations, patents, Copyrights, trademark laws, transportation and logistics laws and regulations Environmental laws. International practices. Confidentiality and proprietary information. Functional application of technologies in Supply Chain: Blockchain, AI, IOT, RFID, AR, VR, ERP Goldratt Supply Chains, Sustainable Supply Chain, Resilient supply chains, Green Supply chain, Lean supply chain.		
		Self-learning: Concepts of Blockchain, AI, IOT, RFID, AR, VR, ERP		
		Tutorial on application of supply chain management concepts in excel		
		Total	**39**	

Textbooks:

1. Sunil Chopra and Peter Meindl, *Supply Chain Management: Strategy, Planning, and Operation*, 6th Edition, Pearson Education

Reference books:

1. Nicoleta Tipi, *Supply Chain Analytics and Modelling: Quantitative Tools and Applications*, 1st Edition.
2. Donald J, *Supply Chain Logistics Management*, 2nd Edition, Bowersox, 2014, McGraw Hills.
3. Copacino, William C, *Supply Chain Management: The Basics and Beyond,* 1997, ST. Lucie Press.
4. Martin Christopher, *Logistics and Supply Chain Management*, 6th Edition.

Online References:

1. The International Journal of Logistics Management https://www.emerald.com/ijlm
2. Supply Chain Management: An International Journal https://www.emeraldgrouppublishing.com/journal/scm

Course Assessment:

ISE:

- To be conducted in any of these forms - Assignment/ Quiz/ Presentation/ Class Test/ Case study etc. of 20 marks.
- ISE 20 marks = 05 marks for attendance + 15 marks for activities.

MSE:

- To be conducted as written examination for 20 marks (on 40% - 50% syllabus)

End Semester Examination:

$ ESE of duration 03 hours are of 80 marks and scaled to 60.

1. Question paper will comprise of 03 questions.
2. Question1(20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
3. Question 2 (40 marks): - Solve any 04 out of 06. All questions carry 10 marks each.
4. Question3(20 marks):- Solve any 04 out of 06. All questions carry 05 marks each.
5. All COs should be mapped as per the weightage in the syllabus.

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
ETPEC 5011	Controls and Sensor Technology	03	--	--	03	--	--	03

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE$			
		ISE	MSE				
ETPEC5011	Controls and Sensor Technology	20	20	60	--	--	100

Course pre-requisite:

1. ETC304: Network Theory
2. ETC305: Signals and Systems

Program Outcomes Addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO5: Engineering Tool Usage.
4. PO11: Lifelong Learning.
5. PSO1: Achieve eminence in domains like signal processing, VLSI, embedded IoT, RF and microwave

Course Objectives:

1. To calculate the mathematical models of a given system using block diagram reduction rules and Mason's gain formula.
2. To provide fundamental concepts of control systems such as time response and Frequency response.
3. To develop concepts of stability and assessment criteria.
4. To provide basic knowledge about the various sensors and transducers.
5. To understand the concept of industrial automation using PLC and SCADA.

Course Outcomes:

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

1. Determine the mathematical models of a given system using block diagram reduction rules and Mason's gain formula.
2. Analyze the dynamic response of first- and second-order control systems using standard test signals
3. Analyze a given system in the time domain with respect to stability.
4. Analyze a given system in Frequency domain with respect to stability.
5. Explain the working principles of various transducers used to measure temperature, displacement, level, pressure, and their application in industry.
6. Develop the concept of industrial automation using PLC and SCADA.

Module No.	Unit No.	Topics	Hrs.	CO
1.0		**Basics of Control Systems and System Modelling**	**04**	**CO1**
	1.1	Introduction: Open and closed loop systems, example of control systems		
	1.2	Modelling of electrical circuits. Analogy between electrical and mechanical system components,		
	1.3	Block diagram reduction techniques and Signal Flow Graphs using Mason's Gain formula.		
2.0		**Response of Control System**	**06**	**CO2**
	2.1	Dynamic Response: Standard test signals and types of errors		
	2.2	Analysis of First and Second Order Control System: First Order System: Analysis for inputs of Unit Step, Unit Ramp and Unit Parabolic, Concept of Time Constant, Steady State Error and types of error constants.		
	2.3	Second Order System: Analysis for inputs of Unit Step, Unit Ramp and Unit Parabolic, Effect of Damping, Time Response Specifications: Delay time, Rise time, Peak Time, Peak Overshoot, settling time, Numerical Problems,		
		Self-Learning: Concept of lag and lead compensator.		
3.0		**Stability Analysis in Time Domain**	**10**	**CO3**
	3.1	Concept of stability: Routh and Hurwitz stability criterion		
	3.2	Root locus Analysis: Root locus concept, general rules for constructing root-locus, root locus analysis of control system		
		Self-Learning: Effect of Controller Parameters (Kp, Ki, Kd) on Root Locus.		
4.0		**Stability Analysis in Frequency Domain**	**10**	**CO4**
	4.1	Introduction: Frequency domain specification, Relationship between time and frequency domain specification of system, stability margins		
	4.2	Bode Plot: Magnitude and phase plot, Method of plotting Bode plot, Stability margins and analysis using bode plot.		
	4.3	Nyquist Criterion: Concept of Polar plot and Nyquist plot, Nyquist stability criterion, gain and phase margin.		
		Self-Learning: Frequency response analysis of RC, RL, RLC circuits.		
5.0		**Sensors and Transducers**	**04**	**CO5**
	5.1	Basics of sensors and Transducers-Active and passive transducers, characteristics and selection criteria of transducers		
	5.2	Displacement and pressure- Potentiometers, pressure gauges, linear Variable Differential Transformers (LVDT) for measurement of pressure and displacement strain gauges.		
	5.3	Temperature Transducers- Resistance temperature detectors (RTD). Thermistors and thermocouples, their ranges and applications		
		Self-Learning: Selection Criteria for Industrial Sensors		
6.0		**Role of Control Systems in Industrial Automation**	**05**	**CO6**
	6.1	Architecture of a typical SCADA system: Human-Machine Interface (HMI), Remote Terminal Units (RTUs), Communication in SCADA.		
	6.2	PLC Instruction Set: Relay Instructions, Logical Instructions, Program Control instructions, Timer and Counter Instructions, Data Handling Instructions		
		Self-Learning: SCADA Communication Protocols (Modbus, Profibus, DNP3)		
		Total	**39**	

Textbooks:

1. Ogata K, Yang Y, *Modern Control Engineering* 3 rd Edition, Prentice Hall ,2012.
2. Nagrath, Gopal, *Control System Engineering* 7th Edition, New Age International Private Limited,2021.
3. Gopal M , *Control Systems Principles and Design* 4th Edition, Tata McGraw Hill Publishing Co. Ltd.New Delhi, 2012 .
4. Petruzella, Frank , *Programmable logic controllers* ,4th Edition, McGraw-Hill, Inc, 2017.
5. Lamb, Frank, *Industrial automation: hands-on* 1st Edition, 2013, McGraw-Hill Education, 2013.

Reference books:

1. Norman, *Control System Engineering* 3 rd edition, John Wiley & sons,2004.
2. Benjamin C.Kuo, *Automatic Control Systems* 7 th edition, Pearson education, 1995.
3. Khaled Kamel and Eman Kamel, *Programmable Logic Controllers: Industrial Control* 1 st Edition, Tata McGraw Hill Publishing Co. Ltd,2013.
4. Stuart A. Boyer, *Supervisory Control and Data Acquisition (SCADA) Systems* 4 th edition, International Society of Automation, 2016.

Online References:

1. Course: Control Systems By Prof. C. S. Shankar Ram (IIT Madras); Web Link: https://swayam.gov.in/nd1_noc20_ee90/preview
2. NPTEL Course: Control Systems By Prof. C.S. Shankar Ram, Department of Design Engineering, IIT Madras: - Web link- https://nptel.ac.in/courses/107/106/107106081/

Course Assessment:

ISE:

- To be conducted in any of these forms - Assignment/ Quiz/ Presentation/ Class Test/ Case study etc. of 20 marks
- ISE 20 marks= 05 marks for attendance + 15 marks for activities.

MSE:

- To be conducted as written examination for 20 marks (on 40% - 50% syllabus)

End Semester Examination:

$ ESE of duration 03 hours is 80 marks and scaled to 60.

1. The question paper will comprise 03 questions.
2. Question1 (20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
3. Question 2 (40 marks): - Solve any 04 out of 06. All questions carry 10 marks each.
4. Question 3 (20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
5. All COs should be mapped as per the weightage in the syllabus.

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
ETPEC5012	Internet of Things	03	--	--	03	--	--	03

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE$			
		ISE	MSE				
ETPEC 5012	Internet of Things	20	20	60	--	--	100

Course pre-requisite:

1. FEC201: Applied Mathematics-II

Program Outcomes Addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO11: Lifelong Learning
4. PSO1: Achieve eminence in domains like signal processing, VLSI, embedded IoT, RF and microwave

Course Objectives:

1. To understand the fundamentals of IoT, its architecture, enabling technologies, and real-world impact across various domains.
2. To study sensors, actuators, smart objects, and communication technologies used in IoT systems.
3. To understand the layered architecture of IoT systems including sensing, communication, and application layers.
4. To learn communication protocols and transport mechanisms used in IoT applications.
5. To explore IoT applications in various domains such as smart homes, industries, cities, environment, and agriculture.
6. To develop practical IoT systems using hardware platforms and software tools.

Course Outcomes:

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

1. Explain IoT concepts, architectures (oneM2M, IoTWF), and analyze IoT applications, challenges, and computing paradigms like edge, fog, and cloud.
2. Describe and analyze sensors, actuators, wireless sensor networks, and IoT access technologies such as RFID, BLE, ZigBee, LoRa, and NB-IoT.
3. Explain and analyze the IoT functional stack including devices, network layers, and application/analytics layers for data-driven decision making.
4. Compare and apply IoT protocols such as MQTT, CoAP, and web-based protocols for efficient data communication.
5. Analyze and evaluate IoT solutions across different domains including home automation, smart cities, healthcare, environment, and energy systems.
6. Design and implement basic IoT applications using Raspberry Pi, Python programming, APIs, and data analytics/visualization techniques.

Module No.	Unit No.	Topics	Hrs.	CO
1.0		**Introduction to Internet of Things (IOT)**	**06**	**CO1**
	1.1	Overview of IoT and Digitization.		
	1.2	IoT Impact- connected roadways, connected factory, smart connected buildings, smart creatures, convergence of IT and OT, IoT challenges		
	1.3	The oneM2M IoT standardized architecture, The IoT world forum (IoTWF) standardized architecture, IoT data management and compute stack- design considerations and data related problems.		
	1.4	Fog Computing, Edge Computing, The hierarchy of Edge, Fog and Cloud		
		Self-learning: IoT Growth- A statistical View		
2.0		**Things in IoT**	**09**	**CO2**
	2.1	Sensors/Transducer-definition, principles, Classifications, types, characteristics and specifications, Actuators- Definition, Principles, Classifications, Types, Characteristics and Specifications, Smart Object- Definition, Characteristics and Trends		
	2.2	Sensor Networks – Architecture of Wireless Sensor Network, Network Topologies.		
	2.3	IoT Access Technologies- Radio Frequency Identification Technology, NFC (Near Field Communication), Bluetooth Low Energy (BLE), IEEE 802.15.4– Standardization and Alliances, ZigBee. LORA, NBIoT.		
		Self-learning: MicroElectro-Mechanical Systems (MEMS), LTE-A (LTE Advanced)		
3.0		**The Core IoT Functional Stack**	**08**	**CO3**
	3.1	Layer 1 – Things: Sensors and Actuators Layer		
	3.2	Layer 2 – Communications Network Layer, Access Network Sublayer, Gateways and Backhaul Sublayer, Network Transport Sublayer, IoT Network Management Sublayer. Visualization of a sensor network using NS2 or any lightweight simulator.		
	3.3	Layer 3 – Applications and Analytics Layer, Analytics Vs. Control Applications, Data Vs. Network Analytics, Data Analytics Vs. Business Benefits.		
		Self-learning: Smart Services		
4.0		**Application Protocols for IoT**	**04**	**CO4**
	4.1	The Transport Layer, IoT Application Transport Methods		
	4.2	IoT Application Layer Protocols – CoAP and MQTT		
	4.3	Generic Web-Based Protocols		
		Self-learning: XMPP, DDS, device spoofing, insecure pairing, weak credentials and unencrypted communication		
5.0		**Domain Specific IoTs**	**06**	**CO5**
	5.1	Home Automation – Smart Lighting, Smart Appliances, Intrusion Detection, Smoke/Gas Detectors, Industry – Machine Diagnostics and Prognosis, Indoor Air Quality Monitoring, Health and Lifestyle – Health and Fitness Monitoring, Wearable Electronics, Apple AirTag and the Find My network, Google's Find My Device network and Amazon Sidewalk.		
	5.2	Cities – Smart Parking, Smart Lighting, Smart Roads, Structural Health Monitoring, Surveillance, Environment – Weather Monitoring, Air Pollution Monitoring, Noise Pollution Monitoring, Forest Fire Detection, River Floods Detection		

	5.3	Energy – Smart Grids, Renewable Energy Systems, Inventory Management, Smart Payments, Smart Vending Machines, Agriculture – Smart Irrigation, Green House Control.		
		Self-learning: Overview and Role of Storage in Cloud / Server /Inhouse Storage		
6.0		**Create your own IoT**	**06**	**CO6**
	6.1	IoT Hardware - Raspberry Pi, Raspberry Pi interfaces		
	6.2	IoT Software – Linux on RPi, programming Rpi with Python, other IOT devices, API development, for making front ends, REST and JSON-LD IOT Data Analytics and Visualization- Analysis of data using the Python language libraries (modules), Visualization and interpretation of Data, Data Cleaning in IoT.		
		Self-learning: Particle Photon, Beaglebone Black		
		Total	**39**	

Textbooks:

1. Arshdeep Bahga, Vijay Madisetti, *Internet of Things- a Hand on Approach*, Universities Press, 2014.
2. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry, *IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things*, 1st Edition, Pearson Education, 2017 (Cisco Press Indian Reprint).

References:

1. Raj Kamal, *Internet of Things: Architecture and Design Principles*, McGraw Hill Education, Second edition, June 2022.
2. Srinivasa K G, *Internet of Things*, CENGAGE Leaning India, 2018.
3. Adrian McEwen, Hakim Cassimally, *Designing the Internet of Things*, Paperback, First Edition, 2013.

Online Resources:

1. Introduction to Industry 4.0 and Industrial Internet of Things, By Prof. Sudip Misra, IIT Kharagpur https://onlinecourses.nptel.ac.in/noc20_cs69
2. How-to-revolutionize-your-business https://www.edx.org/course/industry-4.0
3. Introduction to internet of things by Prof. Sudip Misra, IIT Kharagpur https://onlinecourses.nptel.ac.in/noc21_cs17 - Introduction to internet of things,
4. Embedded Systems Design by Prof. Anupam Basu, IIT Kharagpur. https://onlinecourses.nptel.ac.in/noc21_cs08

Course Assessment:

ISE:

- To be conducted in any of these forms - Assignment/ Quiz/ Presentation/ Class Test/ Case study etc. of 20 marks
- ISE 20 marks= 05 marks for attendance + 15 marks for activities.

MSE:

- To be conducted as written examination for 20 marks (on 40% - 50% syllabus)

End Semester Examination:

$ ESE of duration 03 hours is 80 marks and scaled to 60.

1. The question paper will comprise 03 questions.
2. Question1 (20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
3. Question 2 (40 marks): - Solve any 04 out of 06. All questions carry 10 marks each.
4. Question 3 (20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
5. All COs should be mapped as per the weightage in the syllabus.

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
ETPEC5013	Cryptography and Network Security	03	--	--	03	--	--	03

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE$			
		ISE	MSE				
ETPEC5013	Cryptography and Network Security	20	20	60	--	--	100

Course pre-requisite: --

Program Outcomes Addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO5: Modern Tool Usage
4. PO11: Lifelong Learning
5. PSO2: Become technocrats capable of working in multi-disciplinary fields.

Course Objectives:

1. A basic understanding of classical cryptographic techniques and security concepts and the need for secure communication.
2. Knowledge of symmetric key cryptography, mathematical foundations, and modern block cipher algorithms.
3. Knowledge of asymmetric key cryptography, major public-key algorithms, and key management mechanisms.
4. Understanding cryptographic hash functions, digital certificates, and authentication protocols.
5. The ability to analyze network security threats, DoS attacks, and Internet security protocols with practical relevance.

Course Outcomes:

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

1. Apply basic classical cryptographic techniques to secure communication.
2. Analyze security threats and apply security concepts to secure communication.
3. Explain and apply mathematical foundations and symmetric key cryptographic algorithms.
4. Apply asymmetric key cryptographic techniques and key management mechanisms.
5. Analyze cryptographic hash functions, digital certificates, and authentication protocols.
6. Analyze network security threats, DoS attack mechanisms, and major Internet security protocols.

Module No.	Unit No.	Topics	Hrs.	CO
1.0		**Fundamentals of Cryptography**	**06**	**CO1**
	1.1	Number theory ,Prime Numbers, Prime factorization in cryptography.		
	1.2	Modular arithmetic, Fermat's and Euler's Theorem , Chinese Remainder Theorem		
	1.3	Discrete structure concepts, functions, and algebraic structures.		
		Self-Learning: Properties of modular arithmetic.		
2.0		**Introduction to Security Concepts**	**05**	**CO2**
	2.1	Security Goals, Services, Mechanisms and Types of Security Attacks		
	2.2	The OSI security architecture		
	2.3	Network security model		
		Self-Learning: Case study on attack		
3.0		**Symmetric Key Cryptography**	**06**	**CO3**
	3.1	Block Cipher Principles, Block Cipher Modes of Operation, DES,.		
	3.2	Double DES		
	3.3	Advanced Encryption Standard (AES)		
		Self-Learning Topics: Tripple DES		
4.0		**Asymmetric Key Cryptography and Key Management**	**08**	**CO4**
	3.1	Public key cryptography, Principles of public key cryptosystems, The RSA algorithm.		
	3.2	Key management Techniques: Using Symmetric and Asymmetric Algorithms and Trusted Third Party,		
	3.3	Diffie Hellman Key exchange Algorithm		
		Self-Learning: Basics of Linear cryptanalysis .		
5.0		**Cryptographic Hash Functions and Digital Certificates**	**07**	**CO5**
	5.1	Message Integrity, Message Authentication ,Cryptographic Hash Functions, Properties of Secure Hash Function,		
	5.2	User Authentication ,Entity Authentication, MAC, HMAC, MD5, SHA-256.		
	5.3	Digital Certificate: X.509, PKI.		
		Self-learning: SHA3		
6.0		**Network Security**	**07**	**CO6**
	6.1	Network security basics: TCP/IP vulnerabilities (Layer wise), Packet Sniffing, ARP spoofing, port scanning, IP spoofing, TCP SYN flood, DNS Spoofing		
	6.2	Denial of Service: Classic DOS attacks, Source Address spoofing, ICMP flood, SYN flood, UDP flood		
	6.3	Internet Security Protocols: SSL, IPSEC, Secure Email: PGP, Firewalls, IDS and types		
		Self-Learning: Virtual Private Network		
		Total	**39**	

Text books:

1. Bernad Kolman, Robert Busby, Sharon Cutler Ross, Nadeem-ur-Rehman, *Discrete Mathematical Structures*, Pearson Education, 2017.
2. W. Stallings, *Cryptography and Network Security: Principles and Practice*, 7th ed. Pearson, 2017.
3. B. A. Forouzan, *Cryptography and Network Security*, Revised ed. New Delhi, India: Tata McGraw-Hill, 2011.
4. E. Cole, *Network Security Bible*, 2nd ed. Hoboken, NJ, USA: Wiley, Mar. 2011.
5. W. Stallings and L. Brown, *Computer Security: Principles and Practice*, 4th ed. Boston, MA, USA: Pearson, 2018.

References:

1. B. Schneier, *Applied Cryptography: Protocols, Algorithms, and Source Code in C*, 20th Anniversary ed. Hoboken, NJ, USA: Wiley, 2015.
2. A. Kahate, *Cryptography and Network Security*, 4th ed. New Delhi, India: McGraw-Hill Education, 2022.
3. C. Paar, J. Pelzl, and T. Güneysu, *Understanding Cryptography: From Established Symmetric and Asymmetric Ciphers to Post-Quantum Algorithms*, 2nd ed. Cham, Switzerland: Springer, 2024.
4. B. L. Menezes and R. Kumar, *Cryptography, Network Security, and Cyber Laws*, 1st ed. New Delhi, India: Cengage Learning, 2018.
5. Matt Bishop, *Computer Security Art and Science*, Addison-Wesley. 2018.

Online Resources:

1. Introduction to security offered by James Mr. Micken MIT opencourse https://www.bing.com/videos/riverview/relatedvideo?&q=mit+lectures+online+system+security+course&&mid=FEFAA164BBA6571C3982FEFAA164BBA6571C3982&&FORM=VRDGAR
2. Introduction to Cryptography by Tutorial point: Cryptography Tutorial
3. Cryptography and network security by Prof.Saurav Mukhopadhyay NPTEL IIT Kharagpur: Cryptography And Network Security - Course

Course Assessment:

ISE:

- To be conducted in any of these forms - Assignment/ Quiz/ Presentation/ Class Test/ Case study etc. of 20 marks
- ISE 20 marks= 05 marks for attendance + 15 marks for activities.

MSE:

- To be conducted as written examination for 20 marks (on 40% - 50% syllabus)

End Semester Examination:

$ ESE of duration 03 hours is 80 marks and scaled to 60.

1. The question paper will comprise 03 questions.
2. Question1 (20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
3. Question 2 (40 marks): - Solve any 04 out of 06. All questions carry 10 marks each.
4. Question 3 (20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
5. All COs should be mapped as per the weightage in the syllabus.

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
ETPEC 5014	Data Structures and Algorithms	03	--	--	03	--	--	03

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE$			
		ISE	MSE				
ETPEC5014	Data Structures and Algorithms	20	20	60	--	--	100

Course pre-requisite:

1. ETL303 Skill Lab - Python Programming

Program Outcomes Addressed:

2. PO1: Engineering knowledge
3. PO2: Problem analysis
4. PO5: Engineering Tool Usage
5. PO11: Lifelong Learning
6. PSO2: Become technocrats capable of working in multidisciplinary fields.

Course Objectives:

1. To identify the need and significance of data structures as a computer professional.
2. To apply various operations on data structures and select the appropriate one to solve a specific real world problem.
3. To analyze various techniques for the representation of the data in the real world.
4. To understand various graph and tree concepts.
5. To understand the basics of searching and sorting.

Course Outcomes:

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

1. Describe linear and non-linear data structures.
2. Implement stack and queue and apply various operations on it.
3. Design and implement various linked list data structures and apply them to develop linear data structures
4. Apply operations like searching, insertion, and deletion in the tree and graph.
5. Apply various searching and hashing operations.
6. Apply hashing concepts and functions to efficiently store and retrieve data

Module No.	Unit No.	Topics	Hrs.	CO
1.0		**Introduction to Data Structure and Algorithm**	**02**	**CO1**
	1.1	Introduction to Data Structures, Concept of ADT, Types of Data Structures-Linear and Nonlinear, Operations on Data Structures, Applications of Data Structures		
	1.2	Algorithm: Performance characteristics of algorithm, Importance of Algorithm Analysis, Complexity of an Algorithm, Introduction to Asymptotic Analysis and Notations.		
		Self-learning: Role of Abstract Data Types (ADT) in program design.		
2.0		**Stack and Queue**	**08**	**CO2**
	2.1	Introduction to Stack, ADT of Stack, Operations on Stack, Array Implementation of Stack		
	2.2	Applications of Stack- Infix to Postfix Expression Conversion, Infix Expression to Prefix Expression Conversion, Postfix Expression Evaluation		
	2.3	Introduction to Queue, ADT of Queue, Operations on Queue, Array Implementation of Queue, Types of Queue-Circular Queue, Priority Queue, Introduction to Double Ended Queue		
	2.4	Applications of various types of Queues		
		Self-Learning: Well form-ness of Parenthesis using Stack, Multiple queues. Variants of recursion. Case study on priority management.		
3.0		**Linked List**	**08**	**CO3**
	3.1	Introduction, Linked List v/s Array, Representation of Linked List, Types of Linked List - Singly Linked List, Doubly Linked List		
	3.2	Implementation of Stack and Queue using Singly Linked List		
	3.3	Singly Linked List Application-Polynomial Representation and Addition, Doubly Linked List Application		
		Self-Learning: Circular Linked List.		
4.0		**Trees**	**10**	**CO4**
	4.1	Introduction, Tree Terminologies, Binary Tree, Binary Tree Representation, Types of Binary Tree, Binary Tree Traversals, Binary Search Tree, Operations on Binary Search Tree,		
	4.2	Applications of Binary Tree- Expression Tree, Huffman Encoding.		
	4.3	Graph: Introduction, Graph Terminology, Memory Representation of Graph, Operations Performed on Graph.		
	4.4	Graph Traversal, Breadth First Search, Depth First Search, Applications of the Graph, Shortest Path, Minimum Spanning Tree.		
		Self-Learning: Data structures for web graph and google map.		
5.0		**Searching and Sorting**	**06**	**CO5**
	5.1	Searching: Sequential Search, Index Sequential Search, Binary Search		
	5.2	Sorting: Bubble Sort, Quick Sort, Merge Sort		
		Self-Learning: Selection Sort, Insertion Sort		

6.0		Hashing	05	CO6
	6.1	Hashing-Concept, Hash Functions, Common hashing functions		
	6.2	Collision resolution Techniques		
		Self-Learning: Hashing in Advanced Applications: Hashing in databases (indexing, hash joins), Hashing in distributed systems (DHT, consistent hashing in cloud systems),Hashing for data deduplication		
		Total	**39**	

Text books:

1. Jean Paul Tremblay, P. G. Sorenson, *Introduction to Data Structure and its Applications*, McGraw-Hill Higher Education,2nd Edition, 1984.
2. Ellis Horowitz, Sartaj Sahani and Sanguthevar Rajasekaran, *Fundamentals of Computer Algorithms*, Universities Press (India) Pvt. Ltd, Second Edition, 2008.
3. Allen Downey, Jeffrey Elkner, Chris Meyers, *Learning with Python*, Dreamtech Press, 2015.

References:

1. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, Clifford Stein, *Introduction to Algorithm,* MIT Press**,** 4th Edition, 2022.
2. Sanjoy Dasgupta, Christos Papadimitriou, Umesh Vazirani, *Algorithms*, Tata McGrawHill Edition, 2023.

Online Resources:

1. Data Structures and Algorithms Design — offered by IIT Kanpur, By Prof. Nitin Saxena. https://onlinecourses.nptel.ac.in/noc25_cs81/preview
2. Data Structures and Algorithms — offered by IIT Bombay, by Prof. Deepak B. Phatak & Prof. Abhiram Ranade https://onlinecourses.nptel.ac.in/noc25_csXX/preview
3. Data Structures and Algorithms Specialization — offered by University of California San Diego & HSE https://www.coursera.org/specializations/data-structures-algorithms
4. Data Structures and Algorithms (Beginner Level) — offered by University of California Davis https://www.coursera.org/learn/data-structures-algorithms

Course Assessment:

ISE:

- To be conducted in any of these forms - Assignment/ Quiz/ Presentation/ Class Test/ Case study etc. of 20 marks
- ISE 20 marks= 05 marks for attendance + 15 marks for activities.

MSE:

- To be con
-
- ducted as written examination for 20 marks (on 40% - 50% syllabus)

End Semester Examination:

$ ESE of duration 03 hours is 80 marks and scaled to 60.

1. The question paper will comprise 03 questions.
2. Question1 (20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
3. Question 2 (40 marks): - Solve any 04 out of 06. All questions carry 10 marks each.
4. Question 3 (20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
5. All COs should be mapped as per the weightage in the syllabus.

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
ETL501	Digital Communication Lab	--	02	--	--	01	--	01

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE			
		ISE	MSE				
ETL501	Digital Communication Lab	--	--	--	25	25	50

Course pre-requisite:

1. ETL401: Principles of Communication Engineering Lab

Program Outcomes Addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO5: Engineering tool usage
4. PO7: Ethics
5. PO8: Individual and Collaborative teamwork
6. PO9: Communication
7. PSO1: Achieve eminence in domains like signal processing, VLSI, embedded IOT, RF and microwave.

Lab Objectives:

1. To learn the basics of information theory and source coding.
2. To explain the basic principles of digital pulse modulation and multiplexing.
3. To compare different line coding formats.
4. To analyze various digital modulations techniques.

Lab Outcomes:

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

1. Apply the elements of information theory in Communication Systems.
2. Compare different source coding techniques.
3. Compare PCM and DM waveforms.
4. Analyze different line coding formats.
5. Analyze various digital modulation techniques.

Suggested List of Experiments:		
Sr. No.	**Title of Experiments**	**LO**
1	**Calculation of self-information, source entropy and average information rate:** a. Given a discrete memoryless source emitting symbol with known probabilities, b. Determine the self-information of each symbol, c. Compute the total source entropy, and d. Evaluate the average information rate when the source emits symbols at a specified rate.	LO1
2	**Calculation of channel capacity, bandwidth, and S/N**: a. For a communication channel with defined bandwidth and noise characteristics, b. Calculate the maximum achievable channel capacity using Shannon's formula. c. Determine the required bandwidth or signal-to-noise ratio (S/N) to achieve a target data rate.	LO1
3	**Calculation of Shannon's limit**: a. For a data transmission system operating at a given bit rate and bandwidth, compute the minimum S/N (in dB) required according to Shannon's limit. b. Compare the theoretical limit with practical S/N values.	LO1
4	**Huffman code generation and efficiency calculation**: a. Given a set of source symbols and their probabilities, b. Construct the Huffman coding tree, c. Generate uniquely decodable variable-length codes, d. Compute the average codeword length, and evaluate the coding efficiency and redundancy.	LO2
5	**Shannon-Fano code generation and efficiency calculation**: a. Using a set of symbols with known probabilities, b. Generate the Shannon–Fano code by recursively dividing symbol groups. c. Compute the average code length and determine the efficiency and redundancy of the code.	LO2
6	**LZ code generation and detection**: a. Given an input data sequence, perform LZ compression by generating a dictionary and corresponding encoded output. b. Decode the compressed sequence and verify accurate reconstruction of the original data.	LO2
7	**PCM encoding and decoding**: a. For a sampled analog signal, perform Pulse Code Modulation by quantizing, encoding, and reconstructing the signal. b. Measure quantization noise and evaluate the signal-to-quantization-noise ratio (SQNR).	LO3
8	**DM encoding and decoding**: a. Implement delta modulation for a given analog test signal. b. Observe slope overload and granular noise, perform demodulation, and compare recovered signal quality with the original input.	LO3
9	**Digital multiplexing and de-multiplexing**: a. Design a digital multiplexing scheme (TDM). b. Combine multiple input digital streams into a composite signal and then retrieve each stream through de-multiplexing. Evaluate timing synchronization requirements.	LO3

10	**Line code generation and comparison**: a. Generate different line coding schemes (NRZ, RZ, Manchester, AMI, etc.) for a given bit sequence. b. Compare their bandwidths, DC components, and error performance characteristics.	LO4
11	**Matched filter impulse response for a given input and filter output**: a. Given a known input pulse shape, determine the impulse response of the matched filter. b. Implement the filter, apply the input signal, and analyze the output waveform to verify maximum SNR at the sampling instant.	LO4
12	**Generation (and detection) of Binary ASK**: a. Generate a binary Amplitude Shift Keying waveform for a given bit sequence. b. Implement an ASK demodulator and verify correct detection by comparing transmitted and received bits.	LO5
13	**Generation (and detection) of Binary PSK**: a. Modulate a binary data sequence using Phase Shift Keying (BPSK). b. Design the demodulator, recover the transmitted bits, and analyze the impact of noise on detection accuracy.	LO5
14	**Generation (and detection) of Binary FSK**: a. Produce a binary Frequency Shift Keying signal using two carrier frequencies. b. Implement a coherent or non-coherent detector and verify bit recovery performance.	LO5
15	**Generation (and detection) of QPSK**: a. Generate a Quadrature Phase Shift Keying signal by mapping bit pairs to phase states. b. Implement the QPSK receiver, perform constellation analysis, and verify bit error performance.	LO5
16	**Generation (and detection) of QASK**: a. Using amplitude and phase variations, synthesize a QASK (Quadrature Amplitude Shift Keying) signal. b. Detect and demodulate the received waveform and analyze symbol error performance.	LO5
17	**Generation (and detection) of MSK**: a. Generate a Minimum Shift Keying signal ensuring continuous phase. b. Implement the detection scheme and analyze spectral efficiency and bit recovery in noisy conditions.	LO5
18	**PN sequence generation**: a. Design a linear feedback shift register (LFSR) and generate a Pseudo-Noise (PN) sequence. b. Verify periodicity and autocorrelation properties to confirm maximal length behavior.	LO5
19	**Spread spectrum signal generation and detection**: a. Generate a Direct Sequence Spread Spectrum (DSSS) signal using a PN sequence. b. Implement dispreading at the receiver, measure processing gain, and demonstrate noise/interference rejection.	LO5

Software Tools:
Before starting the experiments, there should be one session on study of development tools like Tina Pro, Google Colab etc. Computation/ Simulation based experiments are also encouraged**.**

Term Work:
The term work should include at least 12 experiments.. Term work will be assessed as Continuous Internal Assessment Practical (CIAP).

Term work Marks:
25 Marks (Total Marks) = 20 Marks (Experiment) + 05 Marks (Attendance)
The final certification and acceptance of term work ensure satisfactory performance of laboratory work and minimum passing marks in term work.

Practical Exam: (2 hours/ 25 Marks)
End-semester Practical and oral exams will be held based on the above syllabus and will be conducted as End Semester Examination Practical (ESEP).

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
ETL502	Computer Communication Networks Lab	--	02	--	--	01	--	01

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE			
		ISE	MSE				
ETL502	Computer Communication Networks Lab	--	--	--	25	--	25

Course pre-requisite:

1. ETL401: Principal of Communication Engineering Lab

Program Outcomes Addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/Development of solutions
4. PO5: Engineering tool usage
5. PO7: Ethics
6. PO8: Individual and Collaborative teamwork
7. PO9: Communication
8. PSO1: Achieve eminence in domains like signal processing, VLSI, embedded IOT, RF and microwave.

Lab Objectives:

1. To develop the ability to design and configure basic and advanced computer network topologies using simulation tools
2. To analyze packet-level communication and understand protocol behavior across the Physical, Data Link, Network, Transport, and Application layers.
3. To implement and evaluate networking concepts in simulated environments.

Lab Outcomes:

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

1. Design and configure computer network topologies using simulation tool and apply concepts of IP addressing, switching, and routing.
2. Analyze network protocols and packet structures using simulation tool, interpreting behavior across different OSI/TCP-IP layers.
3. Simulate routing protocols and analyze the simulation results.
4. Evaluate the performance of application layer services. (such as HTTP, DNS, FTP, and SMTP)

Suggested List of Experiments:		
Sr. No.	**Title of Experiments**	**LO**
1	**To configure and compare various network topologies using cisco Packet Tracer.** a. Design and implement different network topologies such as bus, ring, star, mesh, and hybrid using simulation tool. b. Compare their characteristics in terms of reliability, scalability, cabling requirements, and performance. c. Analyze how the choice of topology affects network communication and fault tolerance.	LO1
2	**To compare various network hardware devices using cisco Packet Tracer.** a. Simulate and study the working of networking hardware devices such as hubs, switches, routers, bridges, access points, and repeaters. b. Compare their functionalities, OSI layer of operation, packet-handling mechanisms, and impact on network efficiency under different traffic conditions.	LO1
3	**To study basic networking Devices using Packet Tracer** a. Explore and analyze the operation of basic networking devices including hubs, switches, and routers. b. Observe how frames and packets are forwarded, how MAC and IP addresses are utilized, and how devices respond to broadcast, unicast, and multicast traffic.	LO1
4	**To implement sub-netting using cisco packet Tracer**. a. Divide a given IP address space into multiple subnets using classful or classless subnetting techniques. b. Configure the network with appropriate subnet masks, assign IPs to devices, and verify connectivity. c. Evaluate the efficiency and address utilization of different subnetting schemes.	LO2
5	**To Study TCP/IP Stack Using Wireshark** a. Capture and analyze network packets using Wireshark to study the functionality of each layer in the TCP/IP protocol stack. b. Examine packet headers, flow control mechanisms, acknowledgements, and the interaction between application, transport, network, and data link layers.	LO2
6	**To configure DHCP server using cisco packet Tracer.** a. Set up a DHCP server in Cisco Packet Tracer to dynamically assign IP addresses to network clients. b. Configure DHCP pools, exclusions, lease times, and verify automatic IP assignments. Study the DHCP Discover–Offer–Request–Acknowledge (DORA) process.	LO2
7	**To study TCP and UDP protocols.** a. Analyze the behavior of TCP and UDP using simulation or packet capture tools. Compare their characteristics including connection setup, reliability, error control, flow control, speed, and real-time suitability. b. Observe packet exchanges of applications using these transport protocols.	LO2
8	**To configure static routing on cisco routers** a. Configure static routing entries on interconnected routers to manually define network paths. b. Verify packet forwarding between different networks, analyze routing tables	LO3
9	**Simulation of dynamic routing protocol RIP using Cisco Packet Tracer.** a. Implement the Routing Information Protocol (RIP) on multiple routers and observe route propagation and updates. b. Verify network convergence, analyze hop-count metrics, and study the limitations of distance-vector routing through simulations of network changes.	LO3

10	**Simulation of dynamic routing protocol OSPF using Cisco Packet Tracer.** a. Configure the Open Shortest Path First (OSPF) protocol on routers in single or multi-area networks. b. Study link-state advertisements, SPF tree formation, cost metrics, route selection, and network convergence behavior under dynamic conditions.	LO3
11	**Simulation of dynamic routing protocol EIGRP using Cisco Packet Tracer.** a. Implement Enhanced Interior Gateway Routing Protocol (EIGRP) and study its features such as DUAL algorithms, successor/feasible successor routes, bandwidth-delay metrics, and rapid convergence. b. Validate routing behavior during topology changes.	LO3
12	**Simulation of dynamic routing protocol BGP using Cisco Packet Tracer.** a. Configure Border Gateway Protocol (BGP) between autonomous systems and study path-vector routing. b. Observe AS-path attributes, route advertisements, policy control, and inter-domain routing behavior.	LO3
13	**To configure the DNS server using Cisco Packet Tracer.** a. Implement a DNS server to map domain names to IP addresses. b. Configure DNS records, assign domain names to devices, and verify name resolution through client systems. c. Study how DNS caching improves lookup performance.	LO4
14	**To configure VLANS, Inter VLAN routing.** a. Create multiple VLANs on network switches and segregate broadcast domains. Implement Inter-VLAN routing using a Layer-3 switch or router-on-a-stick configuration. b. Verify communication between VLANs and analyze how VLANs enhance security and management.	LO4
15	**To configure SSH using Cisco Packet Tracer.** a. Secure remote device access by configuring SSH on Cisco routers or switches. b. Set hostname, domain name, RSA keys, user authentication, and vty line settings. c. Verify encrypted remote login and compare it with Telnet in terms of security.	LO4
16	**To configure MPLS** a. Simulate a simple MPLS-enabled network to study label switching and forwarding. Configure LDP or static label bindings, observe label-switched paths b. Analyze how MPLS improves traffic engineering, QoS, and performance in large networks.	LO4
17	**To configure NAT/PAT routers** a. Implement Network Address Translation (NAT) and Port Address Translation (PAT) to allow private network devices to access external networks. b. Configure dynamic NAT, static NAT, and overload (PAT). Verify translation tables and test connectivity to external hosts.	LO4

Software Tools:
Before starting the experiments, there should be one session on study of software tools such as packet tracer, Wireshark etc.

Term Work:
The term work should include at least 12 experiments and a mini project in a group. Term work will be assessed as Continuous Internal Assessment Practical (CIAP).

Term work Marks:

25 Marks (Total Marks) = 20 Marks (Experiment) + 05 Marks (Attendance)

The final certification and acceptance of term work ensure satisfactory performance of laboratory work and minimum passing marks in term work.

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
ETL503	Electromagnetics Engineering and Antenna Lab	--	02	--	--	01	--	01

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE			
		ISE	MSE				
ETL503	Electromagnetics Engineering and Antenna Lab	--	--	--	25	25	50

Course pre-requisite:

1. ETL401: Principles of Communication Engineering Lab

Program Outcomes Addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/Development of solutions
4. PO5: Engineering tool usage
5. PO7: Ethics
6. PO8: Individual and Collaborative teamwork
7. PO9: Communication
8. PSO1: Achieve eminence in domains like signal processing, VLSI, embedded IOT, RF and microwave.

Lab Objectives:

1. To understand and analyze fundamental antenna parameters such as gain, directivity, bandwidth, and radiation pattern using measurement instruments like a spectrum analyzer.
2. To study and compare different types of antennas including dipole, monopole, loop, Yagi-Uda antenna, and log-periodic antenna.
3. To develop the ability to plot and interpret radiation patterns of various antennas using trainer kits and simulation tools.
4. To design and simulate antennas operating at 2.4 GHz using industry-standard software such as ANSYS HFSS.
5. To understand the design and performance of microstrip antennas such as RMSA, CMSA, and ETMSA.
6. To encourage research-oriented learning through case studies of recent advancements in antenna technologies from reputed journals.

Lab Outcomes:

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

1. Measure and evaluate key antenna parameters using practical instruments like a spectrum analyzer.
2. Identify and differentiate various antenna types based on structure, working principle, and applications.
3. Plot and analyze radiation patterns for different antennas and interpret their characteristics effectively.
4. Design and simulate basic antennas (monopole, dipole, Yagi-Uda, horn) at 2.4 GHz using ANSYS HFSS.
5. Design and analyze microstrip antennas and understand their practical significance in modern communication systems.
6. Review, analyze, and present recent research developments in antenna engineering with technical clarity.

Suggested List of Experiments:		
Sr. No.	**Title of Experiments**	**LO**
1	**Study different Antenna parameters using spectrum analyzer**. a. Measure and analyze key antenna parameters such as gain, bandwidth, VSWR, return loss, and radiation efficiency using a spectrum analyzer and antenna trainer kit. b. Understand the significance of these parameters in evaluating antenna performance for communication systems.	LO1
2	**Introduction to different antenna types** a. Study the construction, working principle, and applications of various antenna types such as dipole, monopole, loop, Yagi-Uda, log-periodic, and horn antennas. b. Compare antenna characteristics based on radiation pattern, directivity, bandwidth, and practical usage.	LO2
3	**Plot radiation pattern of dipole and monopole using antenna trainer kit/ simulation software**. a. Plot and analyze the radiation patterns of dipole and monopole antennas using an antenna trainer kit or simulation software. b. Study their field distribution, beamwidth, and omnidirectional characteristics.	LO3
4	**Plot radiation pattern of folded dipole and various loops antenna using antenna trainer kit/ simulation software**. a. Obtain radiation patterns of folded dipole and various loop antennas through experimental or simulation-based analysis. b. Compare their radiation characteristics and impedance behavior with conventional dipole antennas.	LO3
5	**Plot radiation pattern of directive antenna, Yagi-Uda antenna using antenna trainer kit/ simulation software.** a. Plot and analyze the radiation pattern of a Yagi-Uda antenna. b. Study parameters such as directivity, front-to-back ratio, gain, and beamwidth for directive antennas.	LO2,4

6	**Plot radiation pattern of broad-band antenna, log-periodic antenna using antenna trainer kit/ simulation software.** a. Analyze the radiation pattern and frequency response of a log-periodic antenna. b. Study its broadband behavior, gain variation, and suitability for wideband applications.	LO2,4
7	**Design of broad side and end fire array and study radiation pattern using simulation software.** a. Design broadside and end-fire linear antenna arrays using simulation software. b. Analyze array factor, beam direction, side lobe levels, and overall radiation pattern characteristics.	LO2,4
8	**Analyse and design monopole antenna for a frequency 2.4 GHz using HFSS software** a. Design a monopole antenna resonant at 2.4 GHz using HFSS. b. Simulate and analyze parameters such as S-parameters, VSWR, gain, and radiation patterns.	LO3
9	**Analyse and design dipole antenna for a frequency 2.4 GHz using HFSS software** a. Design a half-wave dipole antenna operating at 2.4 GHz. b. Study its impedance matching, radiation pattern, and performance characteristics using HFSS.	LO3
10	**Design Yagi-Uda antenna for a frequency of 2.4 GHz using HFSS software.** a. Design a multi-element Yagi-Uda antenna at 2.4 GHz using HFSS. b. Analyze gain enhancement, directivity, front-to-back ratio, and radiation pattern.	LO3
11	**Design horn antenna for a frequency of 2.4 GHz using HFSS software.** a. Design a pyramidal or rectangular horn antenna for 2.4 GHz operation. b. Analyze antenna gain, beamwidth, impedance matching, and radiation characteristics.	LO3
12	**Design of RMSA using simulation software.** a. Design a rectangular microstrip antenna and simulate its characteristics. b. Study resonant frequency, return loss, bandwidth, and radiation patterns.	LO5
13	**Design of CMSA using simulation software.** a. Design a circular microstrip antenna and analyze its performance parameters. b. Study polarization characteristics, radiation patterns, and impedance behavior.	LO5
14	**Design of ETMSA simulation software.** a. Design an ETMSA using suitable substrate parameters. b. Analyze its resonant modes, radiation patterns, and bandwidth characteristics.	LO5
15	**Plot radiation patterns of microstrip antenna using Antenna trainer kit.** a. Plot and analyze radiation patterns of different microstrip antennas using an antenna trainer kit. b. Study beam shape, polarization, gain, and comparison with wire antennas.	LO5
16	**Case study of recent reported variations of antenna type**s (Paper from reputed journal is to be referred and thoroughly study and present the report, maximum four students per group)	LO6

Virtual Lab Links:

1. Labster virtual labs are digital simulations of a real-world laboratory environment.
   https://www.labster.com/simulations/electromagnetic-spectrum/
2. This virtual EM laboratory, the concepts of vector calculus and underlying theories in electrostatics, magnetostatics, and time-varying electromagnetic fields are explained using field plots generated by formulae and Finite Element Method (FEM) based computations.
   https://www.ee.iitb.ac.in/course/~vel/

Term Work:

The termwork should include at least 10 experiments. Computation/ simulation-based experiments are encouraged. Term work will be assessed as Continuous Internal Assessment Practical (CIAP).

Term work Marks:

25 Marks (Total Marks) = 20 Marks (Experiment) + 05 Marks (Attendance)

The final certification and acceptance of term work ensure satisfactory performance of laboratory work and minimum passing marks in term work.

Practical Exam: (2 hours/ 25 Marks)

End-semester Practical and oral exams will be held based on the above syllabus and will be conducted as End Semester Examination Practical (ESEP).

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
ETL504	Interpersonal and Career Skills	--	2*+2	--	--	02	--	02

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE$			
		ISE	MSE				
ETL504	Interpersonal and Career Skills	--	--	--	50	--	50

Course pre-requisite:

1. FEC205: Professional Communication Techniques.

Program Outcomes Addressed:

1. PO6: The Engineer and the World
2. PO7: Ethics
3. PO8: Individual and Collaborative Teamwork
4. PO9: Communication
5. PO10: Project Management and Finance
6. PO11: Lifelong Learning

Course Objectives:

1. To equip students with career development skills to align with the corporate and global requirements.
2. To develop students' ability to conduct and participate in professional business meetings.
3. To apply the knowledge of effective writing skills to produce technical/business documents.
4. To train students in creating effective, dynamic technical/business presentations.
5. To build strong interpersonal skills required for effective workplace communication.
6. To familiarize students with corporate ethics and Intellectual Property Rights.

Course Outcomes:

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

1. Apply essential skills while appearing for recruitment processes or applying for higher education for a successful career.
2. Demonstrate professional behavior to plan, participate in, and document business meetings effectively.
3. Compose well-structured technical/business documents.
4. Design and deliver effective technical/business presentations using suitable strategies.
5. Employ strong interpersonal skills to overcome workplace challenges by understanding professional communication.
6. Apply the principles of corporate ethics and understand Intellectual Property Rights.

Module No.	Unit No.	Topics	Hrs.	CO
1.		**Career Skills**	**08**	**CO1**
	1.1	SWOT Analysis		
	1.2	Cover letter, Resume/ CV: Resume Building Types of Resumes (Chronological, Functional and Combination) Curriculum Vitae Difference between Resume and CV		
	1.3	Group Discussion: Purpose, Types of GD's (Normal, Case-based and Role Plays)		
	1.4	GD Etiquettes, Parameters of Evaluating a GD		
	1.5	Interviews (Face to face and Virtual): Planning and Preparation, Types of Questions, Types of Interviews (Structured, Stress, Behavioral, Problem Solving and Case-based)		
	1.6	Modes of Interviews: Face-to-face, Telephonic,		
	1.7	Virtual Interview Planning and preparation, Online interview etiquettes		
	1.8	Statement of Purpose		
2.		**Business Meetings**	**03**	**CO2**
	2.1	Documentation: Notice, Agenda, Minutes of the Meeting		
	2.2	Conducting Business Meetings: Types of Meetings, Roles and Responsibilities of Chairperson, Secretary and Members, Meeting Etiquettes		
	2.3	Writing Minutes of the Meeting		
3.		**Advanced Technical Writing**	**06**	**CO3**
	3.1	Purpose and Classification of Reports:_Classification based on Subject Matter (Technology, Accounting, Finance, Marketing, etc.), Time Interval (Periodic, One-time, Special)		
	3.2	Function (Informational, Analytical, etc.), Physical Factors (Memorandum, Letter, Short and Long).		
	3.3	Language and Style: Tense, Person and Voice of Reports, Numbering Style of Chapters, Sections and Figures/Tables, Proof-reading through Plagiarism Checkers		
	3.4	Project Report, Prefatory Parts (Front Matter), Report Proper (Main Body), Appended Parts (Back Matter)		
	3.5	Proposals, Format and Style of Technical Proposals, Parts of a Proposal,		
	3.6	Technical Paper Writing:_Parts of a Technical Paper, Language, Style and Formatting, Referencing in IEEE Format		
4.		**Effective Presentation**	**02**	**CO4**
	4.1	Effective Presentation Strategies, defining purpose, analysing audience and location selecting and structuring a presentation, types of presentations aids, using body language and Voice modulation		
	4.2	Group Presentation, Sharing Responsibility in a Team, Building the contents and visuals together, Transition Phases		

5.		**Interpersonal Skills**	**05**	**CO5**
	5.1	Emotional Intelligence		
	5.2	Leadership		
	5.3	Time Management		
	5.4	Decision Making		
	5.5	Responsible Use of social media		
6.		**Corporate Ethics and Intellectual Property Rights**	**02**	**CO6**
	6.1	Introduction to Corporate Ethics		
	6.2	Intellectual Property Rights: Copyrights, Trademarks, Patents, Industrial Designs, Geographical Indications, Integrated Circuits, Trade Secrets (Undisclosed Information)		
		Total	**26**	

Textbooks:

1. Asha Kaul, *Effective Business Communication*, PHI Learning
2. Sanjay Kumar PushpLata, *Communication Skills*, Second Edition: Oxford Publication
3. Rizvi Ashraf, *Effective Technical Communication*, Tata Mc Graw-Hill
4. Jeff Butterfield, *Soft Skills for Everyone*, Cengage Learning
5. Chaturvedi and Chaturvedi, *Business Communication*, Pearson Education
6. Masters Wallace, *Personal Development for Life and Work*, Cengage Learning
7. Manuel G.Velasquez, *Business Ethics-Concepts & Cases*, Pearson Education

Reference Books:

1. Arms, V. M., *Humanities for the Engineering Curriculum*, McGraw-Hill.
2. Bovée, C. L., & Thill, J. V., *Business Communication Today*, Pearson.
3. Butterfield, J.: Verbal communication, *Soft skills for a digital workplace, Cengage* Learning.
4. Masters, L. A., Wallace, H. R., & Harwood. L, *Personal Development for Life and work, Cengage* Learning.
5. Robbins, S. P., Judge, T. A., & Campbell, T. T., *Organizational behavior*, Pearson.
6. Meenakshi Raman, Sangeeta Sharma, *Technical Communication, Principles and Practice*, Oxford University Press
7. Archana Ram, *Place Mentor, Tests of Aptitude for Placement Readiness*, Oxford University Press
8. Sanjay Kumar, Pushpalata, *Communication Skills a Workbook*, Oxford University Press.

Online Resources:

1. Directorate General of Training (DGT).
Employability Skills Curriculum. Ministry of Skill Development & Entrepreneurship, Government of India,
https://www.dgt.gov.in/sites/default/files/Employability_Skills_Curriculum.pdf.
2. Punjab State Open University (PSOU).
Technical Writing and IPR Syllabus. PSOU,
https://psou.ac.in/asset/docs/course_syllabus/20221125183033165f0acdb4.pdf.
3. National Institute of Technology Kurukshetra (NITKKR).
Professional Ethics and Intellectual Property Rights (HSIR-13). NITKKR,
https://nitkkr.ac.in/wp-content/uploads/2024/07/Professional-Ethics-and-IPR-HSIR-13.pdf.
4. Punjab Engineering College (PEC).
B.Tech Communication and Humanities Syllabus. PEC Chandigarh,
https://pec.ac.in/sites/default/files/2025-07/B.Tech_.-Syllabus-CMH.pdf.

5. Commonwealth Corporation.
Career Readiness Curriculum Guide. Comm Corp, https://commcorp.org/wp-content/uploads/2016/07/resources_eyf-career-readiness-curriculum-guide.pdf.

Course Assessment:

Term Work (CIAP): **50 marks**

Term Work shall consist of Oral and Written assessment for 25 marks each

1. Oral evaluation to be conducted for 25 marks through:
   a) Report Presentation 10 marks
   b) Group Discussion 10 marks
   c) Mock Interviews 05 marks

6. Written evaluation to be conducted for 25 marks through:
   a) Project Report (25 to 30 pages) 10 marks
   b) Assignments based on all modules 10 marks
   c) Attendance 05 marks

End-semester written and oral assessment will be held based on the above scheme for 50 marks.

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
MDML5011	Machine Learning Lab	--	02	--	--	01	--	01

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE			
		ISE	MSE				
MDML5011	Machine Learning Lab	--	--	--	25	--	50

Course pre-requisite:

1. ETL303: Skill Lab - Python Programming

Program Outcomes Addressed

1. PO1: Engineering Knowledge
2. PO2: Problem Analysis
3. PO4: Conduct investigation of complex problem
4. PO5: Engineering tool usage
5. PO6: The Engineer and The World
6. PO7: Ethics
7. PO8: Individual and collaborative Team work
8. PO9: Communication

Lab Objectives:

1. To introduce Python libraries used for data analysis and machine learning.
2. To explain and perform data preprocessing, including cleaning, handling missing values, and feature scaling.
3. To implement supervised learning algorithms such as regression, classification, decision trees, SVM, and KNN.
4. To apply unsupervised learning techniques including clustering and dimensionality reduction.
5. To evaluate machine learning models using appropriate performance metrics.
6. To design and implement Artificial Neural Networks using Python-based tools.

Lab Outcomes:

Upon completion of this course, Learners will be able to:

1. Apply Python and key ML libraries for preprocessing, visualization, and model building.
2. Demonstrate complete data preprocessing, including missing-value handling, outlier detection, splitting, and feature scaling.
3. Implement and evaluate supervised ML algorithms (regression, classification, decision trees, SVM, and KNN).
4. Analyze unsupervised methods, including clustering and dimensionality reduction.
5. Apply ensemble techniques and compare them with individual models.
6. Design Artificial Neural Networks with Python libraries.

Suggested List of Experiments: Students are required to complete at least 12 experiments.

Sr. No.	Title of Experiments	LO
1	**Study and gain hands-on experience with key Python libraries used in Machine Learning, including Scikit-Learn, TensorFlow, Keras, NumPy, Pandas, Matplotlib, and Seaborn** by performing the following steps: a. Install and import the required libraries and explore basic operations using NumPy and Pandas. b. Visualize a sample dataset using Matplotlib and Seaborn. c. Implement a basic Machine Learning model using Scikit-Learn. d. Build and train a simple neural network using TensorFlow/Keras and observe the results.	LO1
2	**For a given set of training data examples stored in a .CSV file (like Titanicdataset), demonstrate Data Preprocessing in Machine learning with the following steps:** a. Exploring and understanding the dataset. b. Handling Missing values and NULL values. c. Finding Outliers. d. Encoding categorical data. e. Feature scaling etc.	LO2
3	**Develop a Linear Regression model in Python for a given dataset (like Salary vs Experience Dataset) by performing the following steps:** a. Split the dataset into training and testing sets. b. Train the model and determine its parameters (intercept and slope). c. Visualize the results for both the training and testing datasets. d. Use the model to predict outcomes for the test dataset. e. Compare the predicted values with the actual values to evaluate performance.	LO3
4	**Develop a Multiple Linear Regression model in Python using a suitable dataset (like Advertising Dataset) by performing the following steps:** a. Split the dataset into training and testing sets. b. Train the model and determine its parameters (intercept and coefficients for each feature). c. Visualize the relationship between features and the target variable (using appropriate plots). d. Use the trained model to predict outcomes for the test dataset. Compare the predicted values with the actual values to evaluate model performance.	LO3
5	**Implement a Logistic Regression model in Python using a suitable dataset (like Breast Cancer Dataset) by performing the following steps:** a. Load and preprocess the dataset, and split it into training and testing sets. b. Train the Logistic Regression model using Scikit-Learn. c. Make predictions on the test dataset. d. Evaluate the model using metrics such as accuracy, precision, recall, F1-score, and confusion matrix.	LO3
6	**Implement the Decision Tree Classification algorithm in Python using a suitable dataset (like Play Tennis Dataset) by performing the following steps:** a. Load and explore the dataset. b. Split the dataset into training and testing sets. c. Train the Decision Tree model on the training data. d. Visualize the decision tree (if possible).	LO3

	e. Use the model to make predictions on the test data. f. Evaluate the model using performance metrics such as accuracy, confusion matrix, precision, recall, and F1-score.	
7	**Implement the K-Nearest Neighbors (KNN) classification algorithm in Python using a suitable dataset (like Iris Dataset) by performing the following steps:** a. Load and explore the dataset. b. Train the KNN model using different values of *k* (e.g., k = 1, 3, 5). c. Use the model to make predictions on the test data. d. Evaluate and compare the model performance for different *k* values.	LO3
8	**Implement the Support Vector Machine (SVM) classification algorithm in Python using a suitable dataset (like Iris Dataset) by performing the following steps:** a. Load and preprocess the dataset, and split it into training and testing sets. b. Train the SVM classification model using Scikit-Learn. c. Make predictions on the test dataset. d. Evaluate the model using metrics such as accuracy, confusion matrix, precision, recall, and F1-score.	LO3
9	**Implement the K-Means clustering algorithm in Python using a suitable dataset (Mall Customers Dataset) by performing the following tasks:** a. Apply K-Means clustering with different values of k (e.g., 2, 3, 5) b. Visualize the resulting clusters using appropriate plots (such as scatter plots) c. Compare how the clustering changes with different values of k.	LO4
10	**Implement the Hierarchical Clustering algorithm in Python using a suitable dataset (like Mall Customers Dataset) by performing the following tasks:** a. Apply Hierarchical Clustering using different linkage methods (single, complete, average, and ward). b. Visualize the clustering process using a dendrogram. c. Form clusters and visualize the final grouped data points.	LO4
11	**Implement the DBSCAN (Density-Based Spatial Clustering) algorithm in Python using a suitable dataset (like Mall Customers Dataset) by performing the following tasks:** a. Apply DBSCAN clustering by selecting appropriate parameters (eps and min_samples) . b. Identify core points, border points, and noise (outliers) . c. Visualize the resulting clusters and noise points using suitable plots.	LO4
12	**Implement Principal Component Analysis (PCA) in Python on a suitable dataset (like Iris dataset)to reduce its dimensionality by extracting the first n principal components (e.g., n = 1, 2, …, 10). Perform the following tasks:** a. Apply PCA to compute principal components. b. Select different values of n and observe the variance explained. c. Visualize the data using the reduced components (e.g., 2D plot).	LO4
13	**Implement ensemble learning using the bagging technique with the Random Forest algorithm in Python on a suitable dataset (Iris dataset) by performing the following tasks:** a. Train the Random Forest model on the training data. b. Use the model to make predictions on the test data. c. Evaluate the model's performance using metrics such as accuracy, etc.	LO5

14	**Implement ensemble learning using boosting techniques (AdaBoost or XGBoost) in Python for a classification or regression task using a suitable dataset [Breast Cancer Dataset (Best for Classification) and California Housing Dataset (Best for Regression)]. Perform the following tasks:** a. Load and split the dataset into training and testing sets. b. Train the boosting model (AdaBoost or XGBoost) on the training data . c. Use the model to make predictions on the test data d. Evaluate the model's performance using appropriate metrics (e.g., accuracy for classification or mean squared error for regression)	LO5
15	**Design and implement the McCulloch–Pitts neuron model in Python and demonstrate basic logical operations by performing the following steps:** a. Define the neuron model with appropriate weights and threshold values. b. Implement the model to perform logical operations such as AND, OR, and NOT. c. Test the model with different input combinations. d. Analyze the outputs to verify the correctness of each logical operation.	LO6
16	**Design and implement the Single Layer Perceptron learning algorithm to simulate basic logic gates such as AND, OR, and NOT by performing the following steps:** a. Define the perceptron model with suitable input weights, bias, and learning rule. b. Train the perceptron for basic logic gates such as AND, OR, and NOT using appropriate input-output pairs. c. Test the trained model with different input combinations. d. Analyze the outputs to verify the correctness of each logic gate operation.	LO6
17	**Design and implement an Artificial Neural Network (ANN) using the Backpropagation algorithm in Python on a suitable dataset (like Iris dataset) by performing the following steps:** a. Load and preprocess the dataset, and split it into training and testing sets. b. Design and train the ANN model using the Backpropagation algorithm. c. Test the trained model on the test dataset. d. Evaluate the model performance using appropriate metrics such as accuracy or loss.	LO6

Textbooks:

1. A. C. Müller and S. Guido, Introduction to Machine Learning with Python, 1st ed. Sebastopol, CA, USA: O'Reilly Media, 2016.
2. F. Chollet, Deep Learning with Python, 3rd ed. Shelter Island, NY, USA: Manning Publications, 2025.
3. I. Goodfellow, Y. Bengio, and A. Courville, Deep Learning, 1st ed. Cambridge, MA, USA: MIT Press, 2016.

Reference books:

1. C. M. Bishop, Neural Networks for Pattern Recognition, 1st ed. Oxford, U.K.: Oxford University Press, 1995.

Online Resources:

1. NPTEL course: Introduction to Machine Learning (in Hindi) by Prof. Anubha Gupta, IIT Delhi, available at: NPTEL
2. Google's Machine Learning Crash Course: https://developers.google.com/machine-learning/crash-course
3. Fast.ai Practical Deep Learning: https://www.fast.ai/
4. DeepLearning.AI (Andrew Ng): https://www.deeplearning.ai/
5. Kaggle Learn: https://www.kaggle.com/learn
6. Machine Learning Mastery (Jason Brownlee): https://machinelearningmastery.com/
7. Towards Data Science (Medium Blog): https://towardsdatascience.com/
8. Scikit-learn (ML Library for Python): https://scikit-learn.org/
9. TensorFlow End-to-End ML Platform: https://www.tensorflow.org/

Term Work:

- Term work should consist of at least 12 experiments.
- The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. The assignments should be students' centric, and an attempt should be made to make assignments more meaningful, interesting and innovative. Term work will be assessed as Continuous Internal Assessment Practical (CIAP).

Term work Marks (CIAP):

- 25 Marks (Total Marks) =20 Marks (Experiment) + 05 Marks (Attendance)
- The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
MDML5021	Data Analytics and Visualization Lab	--	02	--	--	01	--	01

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE			
		ISE	MSE				
MDML5021	Data Analytics And Visualization Lab	--	--	--	25	--	50

Course pre-requisite:

1. ETL303: Skill Lab - Python Programming

Program Outcomes Addressed:

1. PO1: Engineering Knowledge
2. PO2: Problem Analysis
3. PO3: Design/Development of Solutions
4. PO4: Conduct Investigations of Complex Problems
5. PO5: Engineering Tool Usage
6. PO9: Communication
7. PO11: Lifelong Learning

Lab Objectives:

1. To demonstrate effective use of libraries in data analytics
2. To implement regression methods in real data analytics scenarios.
3. To use time series techniques to perform predictive analysis
4. To Implement text analytics techniques in practical scenarios
5. To use appropriate visualization methods in R and Python for data analysis.
6. To explore data visualization concepts using practical visualization tools.

Lab Outcomes:

Upon completion of this course, Learners will be able to:

1. Explore various data analytics Libraries in R and Python
2. Implement various Regression techniques for prediction.
3. Build various time series models on a given data set.
4. Design Text Analytics Application on a given data set.
5. Interpret various visualizations of given data sets using various tools
6. Develop interactive dashboards integrating data transformation, visualization for professional reporting.

Suggested List of Experiments: Students are required to complete at least 12 experiments.

Sr. No.	Title of Experiments	LO
1	**Data Analytics Libraries Exploration** A retail company has collected large volumes of sales and customer data but lacks meaningful insights. As a data analyst, you are required to explore and utilize data analytics libraries in Python and R to process and visualize the data. **Tasks:** a. Use Python libraries (NumPy, Pandas, Matplotlib) and R libraries (dplyr, tidyr, ggplot2). b. Perform data cleaning and transformation. c. Generate summary statistics. d. Create basic visualizations to identify trends and patterns. **Recommended Datasets:** • https://www.kaggle.com/datasets/rohitsahoo/sales-forecasting • https://archive.ics.uci.edu/ml/datasets/Online+Retail	LO1
2	**Simple Linear Regression** A real estate firm wants to predict house prices based on property size (area). You are required to build a predictive model to understand this relationship. **Tasks:** a. Implement simple linear regression in Python/R. b. Visualize the regression line. c. Evaluate model performance using R^2. d. Interpret the relationship between variables. **Recommended Datasets:** • https://www.kaggle.com/datasets/harishkumardatalab/housing-price-prediction • https://archive.ics.uci.edu/ml/datasets/Housing	LO1
3	**Multiple Linear Regression** A marketing company wants to analyze how different advertising channels (TV, radio, digital) impact product sales. **Tasks:** a. Build a multiple regression model. b. Analyze the influence of each independent variable. c. Perform feature selection. d. Interpret coefficients and statistical significance. **Recommended Datasets:** • https://www.kaggle.com/datasets/ashydv/advertising-dataset • https://www.kaggle.com/datasets/sazid28/advertising.csv	LO2

4	**Time Series Analysis** A supermarket chain wants to analyze monthly sales data to identify trends and seasonal demand patterns for better inventory management. **Tasks:** a. Perform time series decomposition. b. Identify trend and seasonality components. c. Apply rolling statistics. d. Visualize temporal patterns. **Recommended Datasets:** • https://www.kaggle.com/datasets/kyanyoga/sample-sales-data • https://www.kaggle.com/datasets/robikscube/time-series-dataset	LO3
5	**ARIMA Forecasting Model** An energy company wants to forecast future electricity demand based on historical consumption data. **Tasks:** a. Identify ARIMA parameters (p, d, q). b. Build and train the ARIMA model. c. Perform forecasting. d. Compare predicted vs actual values and evaluate accuracy. **Recommended Datasets:** • https://www.kaggle.com/datasets/robikscube/hourly-energy-consumption • https://www.kaggle.com/datasets/sudalairajkumar/daily-temperature-of-major-cities	LO4
6	**Geospatial Data Visualization** A city planning authority needs to visualize infrastructure distribution such as roads, buildings, and land areas for urban planning. **Tasks:** a. Load and preprocess geospatial data (vector and raster). b. Use tools like QGIS / GeoPandas / Rasterio. c. Create spatial visualizations (maps). d. Interpret spatial patterns. **Recommended Datasets:** • https://www.naturalearthdata.com/downloads/ • https://earthdata.nasa.gov/	LO5
7	**Geospatial Data Analytics: Perform supervised classification on Sentinel images to identify Land Use / Land Cover (Google Earth Engine)** An environmental agency wants to monitor land use changes such as urban expansion, deforestation, and water bodies. **Tasks:** a. Use Google Earth Engine. b. Train supervised classification models. c. Classify satellite images (Sentinel data). d. Generate Land Use/Land Cover maps. **Recommended Datasets:** • https://developers.google.com/earth-engine/datasets • https://www.kaggle.com/datasets/apollo2506/satellite-imagery-datasets	LO5

8	**Text analytics: Implementation of Spam filter/Sentiment analysis in python/R**. An e-commerce company wants to analyze customer reviews to understand satisfaction levels and detect spam messages. **Tasks:** a. Preprocess text data (tokenization, stopword removal, etc.). b. Build classification models. c. Perform sentiment/spam detection. d. Evaluate using confusion matrix, accuracy, precision, and recall. **Recommended Datasets:** • https://www.kaggle.com/datasets/lakshmi25npathi/imdb-dataset-of-50k-movie-reviews • https://archive.ics.uci.edu/ml/datasets/SMS+Spam+Collection	LO4
9	**Visualization experiments in R using different Libraries.** A financial analyst needs to present stock market trends and investment insights to stakeholders using effective visualizations. **Tasks:** a. Use R libraries (ggplot2, plotly, lattice). b. Create at least two types of visualizations. c. Ensure clarity and storytelling. d. Interpret key insights. **Recommended Datasets:** • https://www.kaggle.com/datasets/borismarjanovic/price-volume-data-for-all-us-stocks-etfs • https://finance.yahoo.com/	LO5
10	**Visualization experiments in R using different Libraries.** A telecom company is experiencing high customer churn and wants to understand the underlying patterns. As a data analyst, you are provided with customer data including usage patterns, billing information, service complaints, and demographics. Tasks: a. Use R libraries (ggplot2, plotly, lattice). b. Create at least two types of visualizations. c. Ensure clarity and storytelling. d. Interpret key insights. Recommended Datasets: • https://www.kaggle.com/datasets/blastchar/telco-customer-churn	
11	**Visualization experiments in python using different Libraries.** A healthcare organization wants to analyze patient data to identify patterns in disease occurrence and improve treatment planning. **Tasks:** a. Use Python libraries (Matplotlib, Seaborn, Plotly, Bokeh). b. Create advanced visualizations (heatmaps, pair plots, interactive charts). c. Identify trends and correlations. d. Present actionable insights. **Recommended Datasets:** • https://www.kaggle.com/datasets/ronitf/heart-disease-uci • https://www.kaggle.com/datasets/imdevskp/corona-virus-report	LO5

12	**Visualization experiments in python using different Libraries.** A manufacturing company wants to improve production efficiency by analyzing machine performance, downtime, defect rates, and output across different shifts and plants. **Tasks:** a. Use Python libraries (Matplotlib, Seaborn, Plotly, Bokeh). b. Create advanced visualizations such as time-series plots, heatmaps (machine vs downtime), and comparative bar charts. c. Analyze patterns in machine breakdowns, defect rates, and production output. d. Identify correlations between variables such as shift timing, machine usage, and defects. e. Present actionable insights to reduce downtime and improve overall equipment effectiveness (OEE). **Recommended Datasets:** • https://www.kaggle.com/datasets/shivamb/machine-predictive-maintenance-classification	
13	**Build one complete interactive dashboard (Power BI/Tableau)** A business manager requires a real-time dashboard to monitor KPIs such as sales, profit, and regional performance. **Tasks:** a. Use Power BI or Tableau. b. Integrate multiple datasets. c. Apply filters, slicers, and calculated fields (DAX). d. Design interactive and user-friendly dashboards **Recommended Datasets:** • https://www.kaggle.com/datasets/kyanyoga/sample-sales-data • https://www.kaggle.com/datasets/olistbr/brazilian-ecommerce	LO6
14	**Build one complete interactive dashboard (Power BI/Tableau)** A manufacturing company wants to monitor plant performance across multiple units, focusing on KPIs such as production output, downtime, equipment efficiency (OEE), and maintenance costs. The management needs a real-time dashboard to support operational and strategic decisions. **Tasks:** a. Integrate multiple datasets (production logs, maintenance records, downtime reports). b. Apply filters, slicers, and calculated fields (DAX) for KPIs like OEE, MTTR, and MTBF. c. Design interactive dashboards with drill-down capabilities. d. Identify bottlenecks, high downtime areas, and cost drivers. e. Present actionable insights to improve efficiency and reduce operational losses. **Recommended Datasets:** • https://www.kaggle.com/datasets/arnabbiswas1/microsoft-azure-predictive-maintenance	
15	**To explore advanced chart types (waterfall, treemap funnel, map) in Power BI** A logistics company wants to analyze supply chain efficiency and operational performance using advanced visual tools.	LO6

	Tasks: a. Create charts like waterfall, treemap, funnel, and map visuals. b. Integrate visuals into a dashboard. c. Analyze hierarchical and flow-based data. d. Provide insights for decision-making. **Recommended Datasets:** • https://www.kaggle.com/datasets/shashwatwork/dataco-smart-supply-chain-for-big-data-analysis • https://www.kaggle.com/datasets/ramakrishnanthiyagu/supply-chain-management	

Textbooks:

1. EMC Education Services, Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data, Indianapolis, IN, USA: Wiley, 2015.
2. R. V. McCarthy, M. M. McCarthy, and W. Ceccucci, Applying Predictive Analytics: Finding Value in Data, 2nd ed., Cham, Switzerland: Springer, 2019.
3. N. D. Lewis, Introduction to Data Science: A Practical Approach with R and Python, Hoboken, NJ, USA: Wiley, 2017.
4. W. McKinney, Python for Data Analysis: Data Wrangling with pandas, NumPy, and Jupyter, 3rd ed., Sebastopol, CA, USA: O'Reilly Media, 2022.

Reference books:

1. B. Motwani, Data Analytics Using R, New Delhi, India: Wiley, 2015.
2. W. McKinney, Python for Data Analysis: Data Wrangling with pandas, NumPy, and Jupyter, 3rd ed., Sebastopol, CA, USA: O'Reilly Media, 2022.
3. J. Schwabish, Better Data Visualizations: A Guide for Scholars, Researchers, and Wonks, New York, NY, USA: Columbia University Press, 2021.
4. A. A. Albright and W. L. Winston, Business Analytics: Data Analysis and Decision Making, 7th ed., Boston, MA, USA: Cengage Learning, 2023.

Online Resources:

1. Coursera-Data Visualization with Python: Data Visualization with Python | Coursera
2. Microsoft-Fundamentals of data visualization with Power BI: Explore fundamentals of data visualization with Power BI | DP-900T00A-Azure-Data-Fundamentals
3. NPTEL course on R-Programming https://onlinecourses.nptel.ac.in/noc19_ma33/preview

Software Tools

1. Open-Source Data Visualization Tools

Term Work:

- Term work should consist of at least 12 experiments.
- The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. Term work will be assessed as Continuous Internal Assessment Practical (CIAP).

Term work Marks (CIAP):

- 25 Marks (Total Marks) = 20 Marks (Experiment) + 05 Marks (Attendance)
- The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
ETM501	Mini Project 2	--	02$	--	--	01	--	01

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE$			
		ISE	MSE				
ETM501	Mini Project 2	--	--	--	25	25	50

$ indicates the workload of learner (Faculty load: 1 hour /week/4 groups)

Course pre-requisite:

1. FECC204: Digital System Design
2. ETC303: Microprocessor and Microcontroller
3. ETL302: Microprocessor and Microcontroller Lab
4. ETC403: Linear Integrated Circuits
5. ETM401: Mini Project 1B

Program Outcomes Addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/Development of Solutions
4. PO4: Conduct investigations of complex problems
5. PO5: Modern tool usage
6. PO6: The Engineer and the world
7. PO7: Ethics
8. PO8: Individual and Collaborative teamwork
9. PO9: Communication
10. PO10: Project Management and Finance
11. PO11: Life-long learning
12. PSO1: Achieve eminence in domains like signal processing, VLSI, embedded IoT, RF and microwave

Course Objectives:

1. To develop strong foundational knowledge in Embedded Systems, digital design, and FPGA technologies.
2. To enable students to design, implement, and manage FPGA-based and microcontroller-based embedded projects.
3. To train students in selecting appropriate hardware platforms, for specific applications.
4. To familiarize students with industry-relevant tools, workflows, and platforms.
5. To provide hands-on experience with hardware interfacing, communication techniques, and integration.
6. To build industry readiness for VLSI, embedded product development/IOT.

Course Outcomes:

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

1. Demonstrate an understanding of Embedded System fundamentals and FPGA families.
2. Implement/Design Embedded systems / FPGA based digital systems.
3. Interface and integrate hardware components—such as LEDs, switches, seven-segment displays, sensors, and peripherals—using both FPGA boards/ microcontroller-based embedded platforms.
4. Write structured, optimized, and well-documented embedded C/C++ (for MCUs) or Verilog/VHDL (for FPGA) code.
5. Implement, test, refine, and validate the final prototype against specifications.

Plan, document, and execute complete mini projects by applying systematic design methodologies, project management skills, verification/testing procedures, and professional engineering practices.

A. Guidelines to maintain quality of mini project are as follows:

- Students shall form a group of 2 to 4 students either from the same or from different departments.
- Students should do survey and identify needs, which shall be converted into problem statement for mini project in consultation with faculty supervisor/head of department/internal committee of faculties.
- Students shall submit an implementation plan in the form of Smart Report/Gantt/PERT/CPM chart, which will cover weekly activity of mini project.
- A logbook to be prepared by each group, wherein group can record weekly work progress. Guide/ supervisor will verify it and put notes/comments. Both students and faculty will put signatures in it per week.
- Faculty supervisors may give input to students during mini project activity; however, focus shall be on self-learning.
- The solution to be verified with standard tools and procedures and report to be compiled in standard format.
- Suggested steps for mini project selection and implementation
  i. Mini project can be microcontroller based/FPGA based
  ii. Follow these steps
    a. Take specifications, using these specifications design projects.
    b. Select proper microcontroller board / FPGA board considering features and requirements of project (and Create UCF file for FPGA project)
    c. Program it using Embedded C/ Verilog and perform verification of each module (sensors/communication protocol)
    d. Test Functional Simulation and verify using a simulation tool.
    e. For embedded system project - Make hardware connections on GPP of peripherals with microcontroller board and execute the program.
    f. For FPGA project- Synthesize, map and place and route the design using synthesis tool, generate bit stream and download on FPGA, verify results on FPGA hardware/hardware setup made for project

B. Guidelines for Project Report Format:

- The report should not exceed 30 pages. Simply staple it to discourage the use of plastic.
- Report must contain block diagram, circuit diagram, screenshot of outputs and datasheets of microcontrollers and peripherals (Include only required information pages).
- The recommended report writing format is in LaTeX.

C. **Guidelines for Assessment of Mini Project:**
Review/progress monitoring committee may consider the following points for assessment based on general guidelines

Assessment:
Students' group shall complete project in all aspects including,
- Identification of need/problem
- Proposed final solution
- Procurement of components/systems
- Building prototype and testing
- Report prepared as per the standard format

Two reviews should be conducted for continuous assessment,
- First shall be for finalization of problem and proposed solution
- Second shall be for implementation and testing of solutions.

Assessment criteria of Mini Project:
Mini Project shall be assessed based on following criteria;
1. Quality of survey/ need identification
2. Clarity of Problem definition based on need.
3. Innovativeness in solutions
4. Feasibility of proposed problem solutions and selection of best solution
5. Cost effectiveness and Societal impact
6. Full functioning of working model as per stated requirements
7. Effective use of skill sets
8. Effective use of standard engineering norms
9. Contribution of an individual's as member or leader
10. Clarity in written and oral communication

Term Work (CIAP)
- The term work should include one project. Term work will be assessed as Continuous Internal Assessment Practical (CIAP).
- In continuous assessment, focus shall also be on each individual student, assessment based on individual's contribution in group activity, their understanding and response to questions.
- Distribution of Term work (25 Marks) shall be as below:
    - Marks awarded by guide/supervisor based on logbook: 10
    - Marks awarded by review committee: 10
    - Quality of Project report: 05
- The final certification and acceptance of term work ensure satisfactory performance of project work and minimum passing marks in term work.

Practical/Oral Exam: (2 hours/ 25 Marks)
End-semester Practical and oral exams will be held based on the demonstration of the project and will be conducted as End Semester Examination Practical (ESEP).

Embedded System based Project:

Topics and study material:

1. **Controller boards and Programming – Embedded C:** ARM LPC 21XX (2148), STM32 boards and Texas MSP 430 lunchbox https://predictabledesigns.com/how-to-select-the-microcontroller-for-your-new-product/
2. **Interfacing Sensors and peripherals using Embedded C:**
   Study Material: For LCD interfacing with MSP430 LaunchPad https://microcontrollerslab.com/lcd-interfacing-msp430-launchpad/#:~:text=LCD%20interfacing%20with%20MSP430%20microcontroller,Now%20I%20will&text=It%20requires%205%20volts%20dc,and%20second%20pin%20is%20vcc
3. **Communication with programming in Embedded C:**
   Study Material: Serial Communication Interface: STM32: https://controllerstech.com/serial-transmission-instm32/#:~:text=Serial%20Transmission%20in%20Stm32&text=UART%20is%20widely%20used%20for,amongst%20which%20communication%20is%20done
   LPC2148: https://www.electronicwings.com/arm7/lpc2148-uart0
   MSP430: https://www.ti.com/lit/ml/slap117/slap117.pdf
4. **Real Time Operating Systems [RTOS]:** RTLinux/ Free RTOS and Mbed OS, Implementation with RTOS
5. **Cloud/Web server:**
   Study Material:
   STM32: https://circuitdigest.com/microcontroller-projects/interfacing- esp8266-with-stm32f103c8-stm32-to-create-a-webserver
   LPC2148: https://circuitdigest.com/microcontroller-projects/iot-based-ARM7- LPC2148-webserver-to-control-an-led
   MSP430: https://circuitdigest.com/microcontroller-projects/sending-email- using-msp430-and-esp8266

FPGA based Project

Topics and study material:

1. **Introduction to FPGA and Synthesis:** Functional simulation, Synthesis and implementation, Synthesis tool flow, Implementation and bit generation, making User constraint files (UCF)Study Material: https://www.xilinx.com/support/university/ise/ise-workshops/ise-fpga-design-flow.html
2. **Introduction to Verilog:** Module definition, port declaration, connecting ports, Writing first Testbench and UCF Study Material: https://www.xilinx.com/support/university/ise/ise-teaching-material/hdl- design.html
3. **Combinational design Using VERILOG:** Programming and FPGA implementation of Adders, 4-bit adders, Mux and decoders, Interfacing LED, switches with FPGA Study Material: https://onlinecourses.nptel.ac.in/noc20_cs63/preview
4. **Sequential design Using VERILOG:** Programming and FPGA implementation of Counters FFs and Shift registers Interfacing Seven Segment Display, UART with FPGA
5. **Project Outline:** Clocked Synchronous State-Machine Analysis, State-Machine Structure, Output Logic, Characteristic Equations, Project Design Steps: Designing state diagram, block diagram of project, Selection of FPGA for project, Selection of synthesis and simulation tool.
6. **Project Implementation and management:** Git Repositories, Learning Project management software like CVS, SVN etc. Project Implementation: Verilog coding, simulation, Synthesis, Bit generation and downloading on FPGA. Result verification and testing.

NOTE:

* **Advanced Microcontroller** may be used as per the student's intellectual ability and strength.

** **RTOS and Cloud/Web Server:** Can be included by Guide /supervisor /Mentor depending upon the need and scope of the project for selected topic and its application.

Reference Books:

1. Dr. K.V.K.K. Prasad, *Embedded Real Time Systems: Concepts, Design & Programming*, Dreamtech Publication.
2. Iyer, Gupta, *Embedded real systems Programming*, TMH
3. Andrew Sloss, Dominic Symes and Chris Wright, *ARM_System_Developers_Guide-Designing_and_Optimizing_System_Software* Elsevier and Morgan Kaufmann Publishers.
4. Samir Palnitkar, *Verilog HDL A guide to Digital Design and Synthesis,* 2nd Edition, Pearson Education, 2009
5. Simon D Monk, *Programming FPGAs: Getting started with Verilog*, 1st Edition, McGraw Hill Eduction- 2016
6. David Romano, *Make FPGAs: Turning Software into Hardware with Eight Fun and Easy DIY*, Shroff/Maker Media; First edition,2016
7. Behrooz Parhami, *Computer Arithmetic Algorithms and Hardware Designs*", Oxford University Press, 2010
8. Clive Maxfield, *Design Warrior's Guide to FPGA*, 2004, Elsevier

Suggested Software tools:

1. Tinkercad : https://www.tinkercad.com/
2. Proteus software
3. KEIL for ARM LPC 2148
4. STM32Cube software
5. MSP Flasher - Command Line Programmer

Online Resouces:

1. Circuit Digest : https://circuitdigest.com
2. Electronics Hub https://www.electronicshub.org
3. Hackster : https://www.hackster.io/
4. Free Tool: https://www.edaplayground.com/
5. Github : https://github.com/
6. NPTEL: Introduction to Embedded System Design (using MSP430) https://onlinecourses.nptel.ac.in/noc20_ee98/preview
7. NPTEL: Embedded System Design with ARM https://onlinecourses.nptel.ac.in/noc20_cs15/preview
8. NPTEL: Embedded systems https://nptel.ac.in/courses/108/102/108102045/

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
ETC601	Digital Signal and Image Processing	03	--	--	03	--	--	03

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE$			
		ISE	MSE				
ETC601	Digital Signal and Image Processing	20	20	60	--	--	100

Course pre-requisite:

1. ETC305: Signals and Systems

Program Outcomes Addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO11: Lifelong Learning
4. PSO1: Achieve eminence in domains like signal processing, VLSI, embedded IoT, RF and microwave

Course Objectives:

1. To introduce discrete-time Fourier analysis and demonstrate DFT/IDFT for signal representation.
2. To implement FFT algorithms and perform fast spectral analysis.
3. To examine image compression transforms.
4. To apply image fundamentals and basic point-processing operations.
5. To execute spatial and frequency-domain enhancement techniques.
6. To apply segmentation methods and perform morphological operations.

Course Outcomes:

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

1. Compute DFT/IDFT and apply DFT properties for signal analysis and convolution.
2. Apply Radix-2 FFT algorithms, interpret flow graphs, and perform spectral analysis.
3. Apply various image compression transforms and compares their performance.
4. Apply point processing techniques such as negative, log, power-law, bit-plane slicing, and contrast stretching.
5. Implement spatial and frequency domain enhancement including smoothing, sharpening, and histogram processing.
6. Apply edge detection, segmentation, and morphological operations for image analysis.

Module No.	Unit No.	Topics	Hrs.	CO
1.0		**Discrete Fourier Transform**	**06**	**CO1**
	1.1	Introduction to DFT, Relation between DFT and DTFT, IDFT, 2D-DFT and 2D-IDFT, Properties of 1D-DFT and 2D-DFT without mathematical proof (Scaling and Linearity, Periodicity, Time Shift and Frequency Shift, Time Reversal, Convolution Property and Parsevals' Energy Theorem). DFT computation using DFT properties.		
	1.2	Transfer function of DT System in frequency domain using DFT. Linear and Circular Convolution using DFT, Convolution of long sequences,		
	1.3	Need of FFT, Radix-2 DIT-FFT algorithm, Radix-2 DIT-FFT Flow graph for N=4 and 8, Inverse FFT algorithm		
		Self-learning: Applications of DFT in filtering, Radix-2 DIF-FFT flow graph for N = 4 and 8, Computational complexity analysis of FFT algorithms.		
2.0		**IIR and FIR Filters**	**04**	**CO2**
	2.1	LTI systems as frequency-selective filters like low pass, high pass, band pass, notch, comb, and all-pass filters. Mapping from s-plane to the z-plane - impulse invariant and bilinear transformation, Design of IIR digital filters (Butterworth) from analog filters using impulse invariant and bilinear transformation techniques.		
	2.2	Characteristics of linear phase FIR digital filters, Symmetric and antisymmetric FIR filter, Location of the zeros of linear phase FIR filters, Minimum, maximum and mixed phase systems. Design of FIR filters using Window techniques (Rectangular, Hamming, Hanning, Blackman, Bartlett), Comparison of IIR and FIR filters		
		Self-learning: Chebyshev IIR filter design, FIR filter design using Frequency Sampling Technique – Type I low pass filter design		
3.0		**Image Compression Transforms**	**06**	**CO3**
	3.1	Introduction to Image Compression, Discrete Cosine Transform (DCT), Discrete Wavelet Transform (DWT)		
	3.2	Karhunen–Loève Transform (KLT), Walsh–Hadamard Transform (WHT), JPEG		
		Self-learning: Introduction to JPEG2000, Principal Component Analysis (PCA).		
4.0		**Digital Image Fundamentals and Point Processing**	**06**	**CO4**
	4.1	Introduction –Steps in Digital Image Processing, concept of spatial and intensity resolution, Relationships between pixels		
	4.2	Point Processing: Image Negative, Log Transform, Power Law transform, Bit plane slicing, Contrast stretching		
		Self-learning: Gamma correction in displays, Intensity level slicing, Applications of bit-plane slicing in data hiding.		

5.0		**Image Enhancement**	**09**	**CO5**
	5.1	Spatial Domain filtering: The Mechanics of Spatial Filtering, Smoothing Spatial Filters-Linear Filters-Averaging filter, Order-Statistic Filters- Median filter, Application of Median filtering for Noise removal, Sharpening Spatial Filters- The Laplacian, Unsharp Masking, Using Frequency Domain Filtering:		
	5.2	Histogram equalization and Histogram Specification		
	5.3	Frequency Domain Filtering Fundamentals, Fourier Spectrum and Phase angle, Steps for Filtering in the Frequency Domain, Correspondence Between Filtering in the Spatial and Frequency Domains, Frequency domain Image Smoothing and sharpening filters - Ideal, Butterworth, Gaussian		
		Self-learning: High-boost filtering, Homomorphic filtering, Bilateral filter		
6.0		**Image Segmentation and Morphology**	**08**	**CO6**
	6.1	Point, Line, and Edge Detection: Detection of Isolated Points, Line detection, edge models, First-Order Derivative operators — The Gradient- Sobel, Prewitt and Roberts		
	6.2	Region Based segmentation: Region Growing, Region Splitting and Merging		
	6.3	Morphology: Erosion and Dilation, Opening and Closing, The Hit-or-Miss Transformation, Boundary extraction, Hole filling		
		Self-learning: Basic global thresholding, Canny edge detection, Morphological skeletonization and thinning, Harris Corner Detection		
		Total	**39**	

Text books:

1. John, G. Proakis, Dimitris and G. Manolakis, *Digital Signal Processing: Principles, Algorithms, and Applications*, Pearson Education, Fourth Edition, 2007.
2. Rafel C. Gonzalez and Richard E. Woods, *Digital Image Processing*, Pearson Education, Fourth Edition 2018.
3. Sridhar S., *Digital Image Processing*, Oxford University Press, Second Edition, 2012.

References:

1. Anand Kumar A., *Digital Signal Processing*, PHI Learning Pvt. Ltd., Third Edition, 2019.
2. Jain, A. K., *Fundamentals of digital image processing*, Prentice Hall, First Edition, 1989.

Online Resources:

1. Digital Signal Processing – Tutorial, TutorialsPoint Editorial Team, available at www.tutorialspoint.com/digital_signal_processing/.
2. Digital Signal Processing (DSP) – Lecture Notes, contributed by various faculty and toppers on LectureNotes, available at https://lecturenotes.in/subject/44/digital-signalprocessing-dsp.
3. Digital Image Processing (DIP) – Lecture Notes, contributed by various faculty and toppers on LectureNotes, available at https://lecturenotes.in/subject/89/digital-imageprocessing-dip.
4. NPTEL Course: Digital Signal Processing by Prof. S. C. Dutta Roy (IIT Delhi), available at https://nptel.ac.in/courses/117/102/117102060/.
5. NPTEL Course: Digital Image Processing by Prof. Santanu Chaudhury (IIT Delhi), available at https://nptel.ac.in/courses/108/105/108105057/.

Course Assessment:

ISE:

- To be conducted in any of these forms - Assignment/ Quiz/ Presentation/ Class Test/ Case study etc. of 20 marks
- ISE 20 marks= 05 marks for attendance + 15 marks for activities.

MSE:

- To be conducted as written examination for 20 marks (on 40% - 50% syllabus)

End Semester Examination:

$ ESE of duration 03 hours is 80 marks and scaled to 60.

1. The question paper will comprise 03 questions.
2. Question1 (20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
3. Question 2 (40 marks): - Solve any 04 out of 06. All questions carry 10 marks each.
4. Question 3 (20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
5. All COs should be mapped as per the weightage in the syllabus.

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
ETC602	Mobile Communication Systems	03	--	--	03	--	--	03

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE$			
		ISE	MSE				
ETC602	Mobile Communication Systems	20	20	60	--	--	100

Course pre-requisite:

1. ETC501: Digital Communication

Program Outcomes Addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO5: Modern tool usage
4. PO11: Lifelong Learning
5. PSO1: Achieve eminence in domains like signal processing, VLSI, embedded IoT, RF and microwave

Course Objectives:

1. To introduce the fundamental principles of mobile communication and provide an understanding of cellular concepts, channel impairments, and mobility management.
2. To acquaint students with the evolution of wireless technologies from 2G to 4G, including network architecture, protocols, and key performance features.
3. To develop an understanding of multiple access techniques and advanced technologies used in modern 4G/LTE systems such as OFDM, MIMO, and carrier aggregation.
4. To provide an overview of next generation 5G networks, focusing on architecture, enabling technologies, and their applications in modern wireless communication systems.

Course Outcomes:

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

1. Describe the fundamental concepts of mobile communication, cellular structure, and frequency of reuse.
2. Describe the architectures and key features of 2G, 3G, and 4G mobile communication systems.
3. Analyze and compare multiple access techniques used in different generations of mobile networks.
4. Explain the advanced techniques used in 4G/LTE deployment, including OFDM, MIMO, carrier aggregation, and handover mechanisms.
5. Describe the architecture, operation, and key enabling technologies of 5G networks such as massive MIMO, mm Wave communication, beamforming, and network slicing.
6. Analyze the performance, challenges, and applications of modern wireless networks in real-world communication scenarios

Module No.	Unit No.	Topics	Hrs.	CO
1.0		**Fundamentals of Mobile Communication**	**06**	**CO1**
	1.1	Cellular system with diagram, explanation of how a call is made from mobile subscriber to landline subscriber with diagram, Frequency reuse concept. capacity of cell, cluster and cellular system, Evaluate and compare the cellular system for different frequency reuse factor		
	1.2	Cluster size N for different i and j shift parameters, effect of cluster size and cell size on system capacity. Coherence bandwidth, delay spread, MMDS, LMDS		
	1.3	Handoff, handoff strategies, need of power control, Adjacent channel and co-channel Interference, derive an expression for S/I ratio, Calculate S/I for given cluster size and comment on the effect of cluster size on S/I ratio. Practical Link budget design using path loss models for NLOS communication.		
	1.4	Techniques for range and capacity improvement, cell splitting. Determine the effect of cell splitting on system capacity and cell sectoring. Effect of cell Sectoring on system capacity and S/I ratio, microcell zone concept.		
		Self-learning: Large scale fading, small scale fading, small cell deployments: different types.		
2.0		**2G, 3G, 4G Technologies**	**08**	**CO2**
	2.1	GSM Network architecture, features and services offered by GSM, GSM signaling Protocol architecture, GSM TDMA frame structure, GPRS architecture, services offered by GPRS, Compare GSM and GPRS based on their features.		
	2.2	IMT 2000, UMTS: Objectives, 3GPP standardization and releases (up to Rel.14), network architecture. W-CDMA air interface, Compare CDMA 2000 and WCDMA, handoff, and power control.		
	2.3	Introduction to 3GPP LTE, 4G-LTE system overview: Goals of 3GPP LTE, Frequency bands and spectrum flexibility, network structure, protocol structure and processes (mobility management and call processing),VoLTE.		
		Self-learning: HSCSD, EDGE ,Various signaling interface, GSM logical channels with their transmission rates		
3.0		**Advanced Techniques for 4G Deployment**	**05**	**CO3**
	3.1	Multi-antenna Techniques: Smart antennas, multiple input multiple output systems (MIMO) Diversity, Mixed (Hybrid Diversity and spatial multiplexing. Adaptive Multiple Antenna Techniques and beamforming.		
	3.2	Cognitive radio: Architecture, Spectrum Sensing. Overview of Cognitive Radio Technology in 5G Wireless, Introduction of SDR		
	3.3	Software Defined Networking (SDN), Network Function Virtualization (NFV), orchestration, and network slicing. Introduction to Internet of Things and Context-Awareness, applications of IoT (IIoT),		
		Self-learning: Modulation and demodulation process for LTE with diagrams.		

4.0		**Introduction to 5G network**	**06**	**CO4**
	4.1	Introduction to 5G Technology, 3GPP defined Features, Requirements, Applications, 5G Services,		
	4.2	5G Network Architecture, Cloud RAN(C-RAN), mobility management and handover. Definitions of Heterogeneous Networks, Radio Resource and Interference Management for Heterogeneous Networks, Traffic offloading scenarios for heterogeneous networks, Energy efficient mechanism with BS sleep mode in green small cell networks, introduction O-RAN.		
		5G NR, Carrier Aggregation in 5G, Use cases of 5G: eMBB, URLLC and mMTC, Advance applications of 5G. Introduction to 6G Technology.		
	4.3	mm Wave: Millimeter bands, mm Wave MIMO challenges, channel modelling, Merits and Demerits, Applications, regulatory guidelines for mm- waves.		
		Self-learning: Physical or Radio layer Technologies - Massive MIMO (Sub 6Ghz)		
5.0		**Multiple Access techniques**	**05**	**CO5**
	5.1	Overview of FDMA, TDMA, CDMA, and Beamforming. Orthogonal Frequency Division Multiple Access (OFDMA), Non orthogonal Multiple Access (NOMA), Different Types: Power Domain NOMA and Code Domain NOMA. Design of OFDMA system with multiple sub carriers using DFT and design of radio frames for OFDMA system		
	5.2	Difference between Orthogonal multiple access and NOMA, Filter Bank multi carrier –Full duplex Radio Techniques, Precoding		
		Self-learning: SDMA		
6.0		**Overview of Wireless Network**	**09**	**CO6**
	6.1	Wireless network architecture, Classifications, Networking issues, wireless IEEE standards,		
	6.2	Comparison of WBAN, WPAN, WLAN, WMAN, WWAN		
	6.3	Planning and design of wireless networks, link budgets for GSM, CDMA 2000 and HSDPA systems.		
	6.4	Introduction to Wireless Adhoc Networks and Wireless Sensor Networks.		
		Self-learning: Open Loop MIMO solutions, Closed Loop MIMO solutions, Antenna Grouping. Codebook based Closed Loop MIMO.		
		Total	**39**	

Textbooks:

1. T. L. Singal, W*ireless communications*, Mc Graw Hill Education
2. Theodore S. Rappaport "*wireless communications - principles and practice*", PEARSON, Second edition, 2002.
3. Vijay K.Garg, W*ireless Communications and Networking*, Morgan–Kaufmann series in Networking-Elsevier,First Edition,2007.
4. Andreas F. Molisch, W*ireless Communications,* WILEY INDIA PVT LTD, Third edition, 2023.
5. R. Vannitham by and S. Talwar, *Towards 5G: Applications, Requirements and Candidate Technologies,* John Willey & Sons, West Sussex, First Edition,2017.

References:

1. Upena Dalal, *Wireless and Mobile Communications*, Oxford university Press, First Edition, 2015
2. W. C. Y. Lee, *Mobile Communication*, Wiley,second edition, 1998.
3. Haykin Simon, *Digital Communications*, John Wiley and Sons, New Delhi, Fourth Edition, 2014.
4. Rose Qingyang Hu, Yi Qian, *Heterogeneous Cellular Networks*, John Wiley & Sons, Ltd., Publication, 2013

Online Resources:

1. Introduction to Wireless and Cellular Communications By Prof. R. David Koilpilla , IIT Madras https://onlinecourses.nptel.ac.in/
2. Fundamentals of MIMO wireless communication, By Surva Sekhar Das, IIT Kharagpur https://onlinecourses.nptel.ac.in/
3. Evolution Of Air Interface Towards 5G, By Surva Sekhar Das, IIT Kharagpur https://onlinecourses.nptel.ac.in/

Course Assessment:

ISE:

- To be conducted in any of these forms - Assignment/ Quiz/ Presentation/ Class Test/ Case study etc. of 20 marks
- ISE 20 marks= 05 marks for attendance + 15 marks for activities.

MSE:

- To be conducted as written examination for 20 marks (on 40% - 50% syllabus)

End Semester Examination:

$ ESE of duration 03 hours is 80 marks and scaled to 60.

1. The question paper will comprise 03 questions.
2. Question1 (20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
3. Question 2 (40 marks): - Solve any 04 out of 06. All questions carry 10 marks each.
4. Question 3 (20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
5. All COs should be mapped as per the weightage in the syllabus.

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
ETC603	Digital VLSI	03	--	--	03	--	--	03

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE$			
		ISE	MSE				
ETC603	Digital VLSI	20	20	60	--	--	100

Course pre-requisite:

1. FEC204: Digital system design
2. ETC302: Electronic Devices and circuits

Program Outcomes Addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/Development of Solutions
4. PO5: Modern tool usage
5. PO11: Lifelong Learning
6. PSO1: Achieve eminence in domains like signal processing, VLSI, embedded IoT, RF and microwave

Course Objectives:

1. To introduce the MOSFET fundamentals, scaling, and CMOS fabrication.
2. To analyze CMOS inverter behavior and assess the characteristics of logic gates.
3. To apply various MOS design logic styles for combinational and sequential circuits.
4. To develop an understanding of semiconductor memory architectures.
5. To explain data path components and system-level design issues.
6. To design digital systems using RTL design methodology.

Course Outcomes:

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

1. Explain MOSFET operation, scaling, and CMOS fabrication basics.
2. Analyze CMOS inverters and assess the behavior of combinational logic circuits.
3. Implement circuits using multiple MOS logic styles.
4. Describe the operating principles and key features of semiconductor memory systems.
5. Analyze data path blocks and system-level timing/clocking issues.
6. Implement RTL models for digital systems using FSM-based design.

Module No.	Unit No.	Topics	Hrs.	CO
1.0		**Review of MOSFET Operation and Fabrication**	**04**	**CO1**
	1.1	Overview of VLSI Design Flow, review of MOSFET operation, MOSFET capacitances, MOSFET scaling, short channel effects		
	1.2	Fabrication process flow of NMOS and CMOS, lambda-based design rules.		
		Self-learning: FinFET, CNTFET, GAA-FET		
2.0		**Combinational CMOS Logic Circuits**	**09**	**CO2**
	2.1	CMOS inverter operation, Voltage Transfer Characteristics (VTC), design of CMOS inverter, layout of CMOS inverter.		
	2.2	Circuit analysis of CMOS Inverters: Critical voltages and noise margins, rise time, fall time, and propagation delay. Design of CMOS Inverter		
	2.3	Realization of CMOS NAND gate, NOR gate, complex CMOS logic circuits, layout of CMOS NAND, NOR		
		Self-learning: Power dissipation		
3.0		**MOS Design Logic Styles**	**10**	**CO3**
	3.1	Static CMOS, pass transistor logic, transmission gate, pseudo NMOS, dynamic logic, domino logic		
	3.2	Setup time, hold time, clocked CMOS SR Latch, CMOS JK latch, edge triggered D-Flip Flop and realization using design styles		
	3.3	Realization of multiplexer, decoder using above design styles		
		Self-learning: Master slave JK Latch, shift register, NORA, Zipper Design style		
4.0		**Semiconductor Memories**	**06**	**CO4**
	4.1	SRAM: 6T SRAM operation, read/write circuits, sense amplifier.		
	4.2	DRAM: 1T and 3T-DRAM operation, refresh operation.		
	4.3	ROM Array: NAND and NOR based ROM array		
	4.4	Flash memory		
		Self-learning: NAND and NOR flash memory, F-N tunneling		
5.0		**Data Path and System Design Issue**	**06**	**CO5**
	5.1	1-bit full adder, ripple carry adder, CLA adder, carry save adder, carry select adder, carry skip adder, Array Multiplier		
	5.2	On chip clock generation and distribution, interconnect delay model,		
		Self-learning: Interconnect scaling, crosstalk, clock comparator		
6.0		**RTL Design**	**04**	**CO6**
	6.1	High Level state machines, RTL design process		
	6.2	RTL design of soda dispenser machine, FIR Filter		
		Self-learning: Implementation of soda dispenser machine , FIR filter		
		Total	**39**	

Text Books:

1. Sung-Mo Kang and Yusuf Leblebici, *CMOS Digital Integrated Circuits Analysis and Design*, Tata McGraw Hill, 3rd Edition, 2012.
2. Jan M. Rabaey, Anantha Chandrakasan and Borivoje Nikolic, *Digital Integrated Circuits: A Design Perspective*, Pearson Education, 2nd Edition, 2003.
3. Frank Vahid, *Digital Design with RTL design, VHDL and VERILOG*, John Wiley and Sons Publisher, 2nd Edition, 2011.

Reference Books:

1. Neil H. E. Weste, David Harris and Ayan Banerjee, *CMOS VLSI Design: A Circuits and Systems Perspective*, Pearson Education, 4th Edition,2011
2. John P. Uyemura, *Introduction to VLSI Circuits and Systems*, Wiley, Student Edition, 2013.
3. R. Jacob Baker, *CMOS Circuit Design, Layout and Simulation*, Wiley, 4th Edition, 2019.

Online Resources:

1. NPTEL: CMOS Digital and VLSI Design, Prof. Sudeb Dasgupta
   https://onlinecourses.nptel.ac.in/

2. NPTEL: VLSI circuits, Prof. S. Srinivasan
   https://onlinecourses.nptel.ac.in/

Course Assessment:

ISE:

- To be conducted in any of these forms - Assignment/ Quiz/ Presentation/ Class Test/ Case study etc. of 20 marks
- ISE 20 marks= 05 marks for attendance + 15 marks for activities.

MSE:

- To be conducted as written examination for 20 marks (on 40% - 50% syllabus)

End Semester Examination:

$ ESE of duration 03 hours is 80 marks and scaled to 60.

1. The question paper will comprise 03 questions.
2. Question1 (20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
3. Question 2 (40 marks): - Solve any 04 out of 06. All questions carry 10 marks each.
4. Question 3 (20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
5. All COs should be mapped as per the weightage in the syllabus.

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
MDMC6013	Natural Language Processing	3	--	--	3	--	--	3

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE$			
		ISE	MSE				
MDMC6013	Natural Language Processing	20	20	60	--	--	100

Course pre-requisite: --

Program Outcomes Addressed

1. PO1: Engineering Knowledge
2. PO2: Problem Analysis
3. PO3: Design/Development of Solutions
4. PO4: Conduct Investigations of Complex Problems
   PO11: Life-Long Learning

Course Objectives:

1. To introduce key concepts, linguistic foundations, text pre-processing and core challenges in Natural Language Processing
2. To build student competency in morphological analysis and language modeling.
3. To explain syntactic structures, tagging and parsing methods for linguistic analysis.
4. To introduce key semantic and discourse concepts for understanding word meaning and document structure.
5. To explore the essential architectures and training approaches underlying large language models.
6. To examine key NLP applications such as NER, QA, machine translation, and modern large-scale language models.

Course Outcomes: Learners will be able to

1. Apply foundational NLP concepts and basic text-processing techniques to analyze language data and develop simple NLP applications.
2. Apply finite-state techniques and N-gram models to analyze morphology and evaluate language models effectively.
3. Analyze POS tagging methods and parsing techniques to interpret and construct accurate syntactic structures of natural language text.
4. Interpret semantic and discourse techniques to understand text meaning and resolve references.
5. Describe key LLM architectures and evaluation methods used in modern NLP systems.
6. Identify major NLP applications and modern LLMs used for real-world language understanding tasks.

Module No.	Unit No.	Topics	Hrs.	CO
1.0		**Introduction to NLP and Text Processing**	**06**	**CO1**
	1.1	What is Natural Language Processing (NLP)? History of NLP, Generic NLP System, Levels of NLP, Ambiguity and Layers of NLP. Challenges of NLP, Processing Indian Languages, Applications of NLP.		
	1.2	Basic Text Processing: Tokenization, Stopword Removal, Stemming and Lemmatization, Regular Expressions		
		Self-learning: Tools for regional languages pre-processing and other functionalities.		
2.0		**Word Level Analysis**	**06**	**CO2**
	2.1	Survey of English Morphology, Inflectional Morphology, Derivational Morphology.		
	2.2	Morphological Models: Dictionary lookup, finite state morphology; Morphological parsing with FST (Finite State Transducer); Lexicon free FST Porter Stemmer algorithm		
	2.3	Language models- N-gram models and smoothing techniques: Laplace smoothing, Good-Turing Discounting, Evaluating language models- perplexity, cross-entropy		
		Self-learning : Noisy channel models, Edit distances, Advance Issues in Language Modelling		
3.0		**Syntax Analysis**	**10**	**CO3**
	3.1	Part-of-speech Tagging: Illustration of Ambiguity in POS, Table Look-up-based and Rule-based POS, Statistical POS Tagging: Hidden Markov Models (HMM) for POS tagging, Viterbi decoding algorithm; Chunking		
	3.2	Context-Free Grammars (CFG) and parse trees; Linguistics of Parsing		
	3.3	Algorithmics of Parsing, Constituency Parsing: Rule Based (Top-Down, Bottom-Up, CYK)		
	3.4	Statistical Parsing, Dependency Parsing and Neural Parsing		
		Self-learning: Evaluating parsers, Parsers based language modelling, regional languages POS tree banks		
4.0		**Semantic and Discourse Processing**	**08**	**CO4**
	4.1	Introduction, Meaning Representation; Lexical Semantics; Study of Various language dictionaries like WordNet, Lexical Relations		
	4.2	Word Embeddings: Word2Vec, CBOW, Skip-gram, GloVe		
	4.3	Word Sense Disambiguation (WSD) methods: Lesk algorithm Document representation: TF-IDF, Doc2Vec		
	4.4	Discourse Structure, Cohesion, Discourse Coherence and Structure , Reference resolution, Reference phenomena, Anaphora resolution using Hobbs algorithm		
		Self-learning: Dictionaries for regional languages, Distributional Semantics, Topic Models , Multimodal Discourse (Text + Image, Text + Video)		

5.0		**Modern NLP with Transformers**	**05**	**CO5**
	5.1	Introduction to Large Language Models (LLM), Fundamental components of the Transformer model		
	5.2	Transformer Architecture and Self-Attention Mechanism, Encoder–Decoder architecture, Introduction to pre-training and fine-tuning paradigms, Pretrained models (BERT, GPT, T5) and fine-tuning, Positional Encoding. Evaluation metrics (BLEU, ROUGE, F1)		
		Self-learning: Transformer Variants-ALBERT, XLNet, Long former.		
6.0		**Applications of NLP**	**04**	**CO6**
	6.1	Named Entity Recognition (NER) , Question Answering System, Machine Translation		
	6.2	Advanced NLP applications: GPT- 4, Llama-3, Claude-3, Mistral and Gemini.		
		Self-learning: Use of NLP in Recommender Systems, Federated Learning for NLP Applications, Develop Chatbot Applications.		
		Total	**39**	

Textbooks:

1. Daniel Jurafsky, James H. and Martin, Speech and Language Processing, Third Edition, Prentice Hall, 2026.
2. Christopher D.Manning and HinrichSchutze, Foundations of Statistical Natural Language Processing, MIT Press, 1999.
3. Pushpak Bhattacharyya and Aditya Joshi, Natural Language Processing, Wiley India Pvt. Ltd., Edition: 2023
4. Dr. Tanmoy Chakraborty, “Introduction to Large Language Models: Generative AI for Text” , Wiley (Wiley India). December 2024.

Reference books:

1. Siddiqui and Tiwary U.S., Natural Language Processing and Information Retrieval, Oxford University Press, 2008.
2. Daniel M Bikel and ImedZitouni — Multilingual natural language processing applications: from theory to practice, IBM Press, 2013.
3. Palash Goyal, Sumit Pandey, Karan Jain. Deep Learning for Natural Language Processing-2018
4. Joseph Babcock, Raghav Bali, “Generative AI with Python and TensorFlow”, Packt Publishing 2021.

Online References:

1. NPTEL Course “Natural Language Processing”: https://onlinecourses.nptel.ac.in/noc23_cs45/preview
2. NPTEL Swayam “Natural Language Processing” https://archive.nptel.ac.in/courses/106/106/106106211/
3. Natural Language Toolkit Book: https://www.nltk.org/book/
4. Stanford Course”Natural Language Processing with Deep Learning”: https://web.stanford.edu/class/cs224n/

Course Assessment:

ISE:

- To be conducted in any of these forms - Assignment/ Quiz/ Presentation/ Class Test/ Case study etc. of 20 marks.
- ISE 20 marks = 05 marks for attendance + 15 marks for activities.

MSE:

- To be conducted as written examination for 20 marks (on 40% - 50% syllabus)

End Semester Examination:

$ ESE of duration 03 hours are of 80 marks and scaled to 60.

1. Question paper will comprise of 03 questions.
2. Question1(20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
3. Question 2 (40 marks): - Solve any 04 out of 06. All questions carry 10 marks each.
4. Question3(20 marks):- Solve any 04 out of 06. All questions carry 05 marks each.
5. All COs should be mapped as per the weightage in the syllabus.

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
MDMC6023	Decision Making and Business Intelligence	03	--	--	03	--	--	03

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE$^{\$}$			
		ISE	MSE				
MDMC6023	Decision Making and Business Intelligence	20	20	60	--	--	100

Course pre-requisite:

1. MDMC5022: Data Analytics and Visualization

Program Outcome Addressed:

1. PO1: Engineering Knowledge:
2. PO2: Problem Analysis
3. PO4: Conduct Investigations of Complex Problems
4. PO5: Engineering Tool Usage
5. PO11: Lifelong Learning

Course Objectives:

1. Understand the fundamentals of decision-making processes.
2. Analyze different types of decisions and decision environments.
3. Explain the architecture and components of Decision Support Systems (DSS).
4. Understand the principles, lifecycle, and architecture of Business Intelligence (BI).
5. Apply concepts of data preparation, integration, and quality management.
6. Explore BI reporting, dashboards, visualization, and emerging BI trends.

Course Outcomes:

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

1. Identify and classify decision types and environments.
2. Apply decision-making techniques such as what-if, sensitivity, and goal-seek analysis.
3. Explain BI architecture, lifecycle, and workflow.
4. Perform data preparation activities.
5. Design basic BI reports, dashboards, KPIs, and visualizations.
6. Evaluate modern BI trends, cloud BI tools, governance principles, and BI applications.

Module No.	Unit No.	Topics	Hrs.	CO
1		**Foundations of Decision Making**	**07**	**CO1**
	1.1	Introduction to Decision Making, Types of Decisions: Structured, Semi-structured, Unstructured, Decision-making environments (Certainty, Risk, Uncertainty), Rational and Bounded Rationality Models, Heuristics, Biases & Cognitive Limitations, Role of Information in Organizational Decision Making, Decision Support in Enterprises.		
		Self-Learning: Case studies of good vs. poor decisions, Decision frameworks used in industry		
2		**Decision Support Systems (DSS)**	**06**	**CO2**
	2.1	DSS Concept, Need and Applications, DSS Architecture (database, model base, UI), Types: Data-driven, Model-driven, Knowledge-driven DSS, What-if, Goal-seek, Sensitivity Analysis, Group Decision Support Systems (GDSS), Executive Information Systems (EIS)		
		Self-Learning: GDSS in corporate problem solving, DSS tools used in supply chain and healthcare		
3		**Introduction to Business Intelligence**	**06**	**CO3**
	3.1	What is BI, Evolution and Scope, BI in Strategic, Tactical and Operational Decisions, BI Lifecycle, BI Architecture, BI Workflow: Data → Insights → Action, Role of BI Analysts.		
		Self-Learning: Case studies of BI adoption		
4		**Data Preparation and Integration for BI**	**08**	**CO4**
	4.1	Importance of Data for BI, Data Sources: Enterprise systems, logs, files, cloud sources, ETL Concepts (high level): Extraction techniques, Data Cleaning and Transformation, Loading into BI-ready storage, Data Quality Dimensions (accuracy, completeness, consistency, timeliness), Data Profiling, Metadata Basics (technical vs. business metadata), Master Data and Reference Data Concepts.		
		Self-Learning: ETL tools overview (Talend, SSIS, Informatica)		
5		**BI Reporting, Dashboards and Visualization**	**07**	**CO5**
	5.1	Principles of Data Visualization, BI Reporting Types: Operational, Tactical, Strategic, KPIs, Metrics and Scorecards, Dashboard Design Principles, Real-time and Self-service Reporting Concepts, BI Reporting Tools Overview.		
		Self-Learning: Best practices in dashboard layouts, Industry examples of KPI dashboards		
6		**BI Applications and Emerging Trends**	**05**	**CO6**
	6.1	Cloud BI(overview), BI Service, BI in Domains: Finance, Healthcare, Retail, Manufacturing, Data Governance and Data Stewardship, BI Ethics, Privacy, Responsible Data Use, Performance Management and Balanced Scorecard.		
		Self-Learning: Big data basic concepts, Digital transformation using BI		
		Total	**39**	

Textbooks:

1. E. Turban, R. Sharda, and D. Delen, Decision Support and Business Intelligence Systems, 10th ed. Pearson, 2014.
2. J. R. Evans, Business Analytics: Methods, Models, and Decisions, 2nd ed. Pearson, 2016.
3. N. Godbole, Business Intelligence, 1st ed. New Delhi, India: Wiley India, 2013.
4. L. T. Moss and S. Atre, Business Intelligence Roadmap: The Complete Project Lifecycle for Decision-Support Applications, 1st ed. Boston, MA, USA: Addison-Wesley, 2003.

Reference books:

1. T. H. Davenport and J. Harris, Competing on Analytics: The New Science of Winning, 1st ed. Harvard Business Review Press, 2007.
2. C. Vercellis, Business Intelligence: Data Mining and Optimization for Decision Making, 1st ed. Wiley, 2009. (BI sections only)
3. W. L. Winston, Microsoft Excel Data Analysis and Business Modeling, 4th ed. Microsoft Press, 2014.
4. P. Ponniah, Data Preparation for Analytics Using SAS, 1st ed. Wiley, 2017.

Online References:

1. Microsoft Power BI Learning Path: https://learn.microsoft.com/power-bi/
2. Tableau Official Learning Portal: https://www.tableau.com/learn
3. AWS Cloud BI (QuickSight)
   Documentation: https://docs.aws.amazon.com/quicksight/

Course Assessment:

ISE: To be conducted in any of these forms - Assignment/ Quiz/ Presentation/ Class Test/ Case study etc. of 20 marks.

MSE: To be conducted as written examination for 20 marks (on 40% - 50% syllabus).

End Semester Examination:

$ ESE of duration 3 hours are of 80 marks and scaled to 60.

1. The question paper will comprise 03 questions.
2. Question 1(20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
3. Question 2 (40 marks): - Solve any 04 out of 06. All questions carry 10 marks each.
4. Question 3(20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
5. All COs should be mapped as per the weightage in the syllabus.

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
MDMC 6063	Organizational Behaviour and Human Resource Management	03	–	01	03	–	01	04

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE$^{\$}$			
		ISE	MSE				
MDMC 6063	Organizational Behaviour and Human Resource Management	20	20	60	25	--	125

Course pre-requisite:

1. Basic understanding of communication and teamwork in project environments
2. Curiosity to learn about human behavior and roles in organizations.

Program Outcomes Addressed

1. PO2: Problem Analysis
2. PO7: Global and Ethical Practices
3. PO8: Collaborative Teamwork
4. PO9: Communication
5. PO10: Project Management and Finance
6. PO11: Lifelong Learning

Course Objectives:

1. To explain fundamental concepts of organizational behaviour, including perception, motivation, leadership, teamwork, and communication, relevant to technical and professional environments.
2. To help students understand individual and group behaviour and develop the ability to apply behavioural principles for effective collaboration in engineering teams.
3. To enable students to apply HRM concepts such as recruitment, training, performance appraisal, and employee engagement in engineering and project-based organizations.
4. To develop skills in conflict resolution, negotiation, and decision-making, preparing students to handle workplace challenges in technical settings.
5. To build the ability to analyze organizational culture and structure, and understand how these factors influence innovation, productivity, and technology-driven work environments.
6. To prepare students to become effective engineering professionals by cultivating leadership, ethical behaviour, interpersonal skills, and a people-oriented mindset essential for managing diverse teams.

Course Outcomes: Learners will be able to

1. Relate to the key concepts of organizational behaviour and human resource management relevant to engineering workplaces.
2. Understand motivation, communication, and leadership theories to improve individual and team performance in technical environments.
3. Apply workplace situations, identify behavioural issues, and evaluate their impact on engineering teams and project outcomes.
4. Analyse HR practices such as recruitment, performance appraisal, and training, and justify their

relevance in engineering industries.

5. Evaluate solutions or strategies for conflict resolution, teamwork enhancement, and employee engagement in engineering projects.
6. Create and demonstrate ethical behaviour, interpersonal skills, and professional conduct, and evaluate their role in shaping an effective organizational culture.

Module No.	Unit No.	Topics	Hrs.	CO
1.0	**1**	**Introduction to Organizational Behaviour and Interpersonal skills**	**5**	**CO1, CO2**
		Meaning and significance of OB, functions, roles and skills related to management; contributing disciplines to the field of OB; challenges and opportunities for OB. Importance of interpersonal skills for engineers; verbal and non-verbal communication; active listening; giving and receiving feedback; building trust and rapport; handling difficult conversations		
		Self-learning : Contributing disciplines to OB, Challenges and opportunities in OB, Importance of interpersonal skills for engineers		
2.0	**2**	**Personality, Perception and Decision Making**	**6**	**CO2**
		Meaning and determinants of personality; major personality traits and attributes; Big Five Model; Job Fit Theory; measuring personality; managing emotions at the workplace. Meaning of perception; factors influencing perception and attitude; Attribution Theory; errors in attribution; link between perception and individual decision making.		
		Self-learning: Meaning of perception; factors influencing perception and attitude		
3.0	**3**	**Values, Attitudes, Job Satisfaction, Learning and Motivation**	**6**	**CO2**
		Definition and types of values; definition and types of attitudes; definition and measurement of job satisfaction; meaning of learning; methods of learning at work. Definition of motivation; theories of motivation (Theory X and Theory Y, Maslow's Need Hierarchy, Two-factor theory, ERG theory, Goal-setting theory, Reinforcement theory, Equity theory, Expectancy theory); motivation from theory to application; link between skill-based plans and motivation theories.		
		Self-learning: Definition and types of attitudes; definition and measurement of job satisfaction; meaning of learning; methods of learning at work.		
4.0	**4**	**Leadership Theories, Styles and Team Influence, Applied Leadership Skills for Engineering Teams**	**6**	**CO2, CO3**
		Concept of leadership; leader vs manager; leadership traits and competencies; overview of major leadership theories (trait, behavioural, contingency/situational); leadership styles and their relevance in technical teams. Leading teams; delegation and empowerment; decision-making and problem-solving as a leader; power and influence; ethical leadership; developing one's own leadership plan.		
		Self-learning: Differences between a leader and a manager.		

5.0	**5**	**Understanding Group Behavior and Teams, Conflicts in the Organization- Organizational Culture and Stress and Organizational Change**	**10**	**CO4, CO5**
		Definition of groups and teams; Stages of group and team development; Group structure: roles, norms, status; Group tasks and decision making; Types of teams - problem-solving, self-managed, cross-functional, virtual etc.; Features of effective teams; Creating and managing effective teams in engineering projects. Definition of conflict; transitions in conflict thought; functional and dysfunctional conflict; the conflict process; negotiation process; bargaining strategies (distributive and integrative). **Organizational Culture and Stress** – Definition of organizational culture; types of culture; functions of culture; culture as an asset and liability; creating and sustaining culture; learning organizational culture; Hofstede's model of culture; **Organizational Stress** – definition of stress; understanding stress and its consequences; sources of stress; managing stress. Meaning of change; forces of change; levels of change; resistance to change; process of change; role of managers in facilitating change.		
		Self-learning : Group structure: roles, norms, status; Group tasks and decision making.		
6.0	**6**	**Introduction to Human Resource Management and Talent Acquisition Performance Management, Development and Employee Engagement**	**6**	**CO4, CO6**
		Meaning, scope and objectives of HRM; role of HR in organizations and specifically in engineering / project-based firms; HR planning; job analysis and job descriptions; recruitment and selection basics. Training and development; performance management and feedback; basics of compensation and rewards; employee engagement and welfare; HR's role in supporting career development of engineers.		
		Self-learning: Meaning, scope and objectives of HRM, ; HR's role in supporting career development of engineers.		
		Tutorial: Case studies, role play and quiz on organizational behavior and Human Resource Management		
		Total	**39**	

Textbooks:

1. Robbins, S. P., & Judge, T. A. (2022). *Organizational behavior* (19th ed.). Pearson.
2. Aswathappa, K. (2018). *Organizational behaviour* (12th ed.). McGraw Hill Education.
3. Dessler, G. (2020). *Human resource management* (16th ed.). Pearson.
4. Armstrong, M. (2021). *Armstrong's handbook of human resource management practice* (16th ed.). Kogan Page.

Reference books:

1. Luthans, F. (2021). *Organizational behavior: An evidence-based approach* (14th ed.). McGraw Hill.
2. Schermerhorn, J. R., Hunt, J. G., & Osborn, R. N. (2020). *Organizational behavior* (14th ed.). Wiley.
3. Mondy, R. W., & Martocchio, J. J. (2016). *Human resource management* (14th ed.). Pearson.
4. Mathis, R. L., Jackson, J. H., & Valentine, S. R. (2019). *Human resource management* (15th ed.). Cengage Learning.

Course Assessment:

ISE:

- To be conducted in any of these forms - Assignment/ Quiz/ Presentation/ Class Test/ Case study etc. of 20 marks.
- ISE 20 marks = 05 marks for attendance + 15 marks for activities.

MSE:

- To be conducted as written examination for 20 marks (on 40% - 50% syllabus)

End Semester Examination:

$ ESE duration of 03 hours is 80 marks and scaled to 60.

6. The question paper will comprise 03 questions.
7. Question1(20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
8. Question 2 (40 marks): - Solve any 04 out of 06. All questions carry 10 marks each.
9. Question 3(20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
10. All COs should be mapped as per the weightage in the syllabus.

CIAP (25-Marks):

At least 06 Tutorials covering the entire syllabus must be given during the "Class Wise Tutorial".

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
ETPEC6011	Embedded Systems	03	--	--	03	--	--	03

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE$			
		ISE	MSE				
ETPEC6011	Embedded Systems	20	20	60	--	--	100

Course pre-requisite:

1. FEC204: Digital System Design
2. ETC303: Microprocessors and Microcontrollers

Program Outcomes Addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/Development of Solutions
4. PO5: Modern tool usage
5. PO11: Lifelong Learning
6. PSO1: Achieve eminence in domains like signal processing, VLSI, embedded IoT, RF and microwave

Course Objectives:

1. To study concepts involved in Embedded Hardware and Software for System realisation.
2. To learn the concepts of modern microcontroller cores like the ARM-Cortex
3. To learn Real-time programming to design time-constrained embedded systems

Course Outcomes:

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

1. Identify and describe various characteristic features and applications of Embedded systems.
2. Analyze and select hardware for Embedded system implementation.
3. Explain the principles of embedded software systems.
4. Evaluate various communication protocols for Embedded system implementation.
5. Compare GPOS and RTOS and investigate the concepts of RTOS.
6. Design a system for different requirements based on life cycle for the embedded system, keeping oneself aware of ethics and environmental issues.

Module No.	Unit No.	Topics	Hrs.	CO
1.0		**Introduction to Embedded Systems**	**04**	**CO1**
	1.1	Definition of Embedded System, Embedded Systems Vs General Computing Systems, Classification, Major Application Areas		
	1.2	Design metrics of Embedded system and Challenges in optimization of metrics		
	1.3	Characteristics and quality attributes (Design Metric) of embedded system. Real time system‘s requirements, real time issues, interrupt latency. Embedded Product development life cycle.		
		Self-learning: Application area in IoT		
2.0		**Embedded Hardware Elements**	**06**	**CO2**
	2.1	Features and architecture of Embedded cores- µC, ASIC, ASSP, SoC, FPGA, RISC and CISC cores. Types of memories.		
	2.2	ARM Cortex-M3 Features, Architecture, Programmer’s model, Special Registers, Operating Modes and States, MPU, Memory map and NVIC.		
	2.3	Low power: - Need and techniques. Case study of Low Power modes in Cortex-M3		
		Self-learning: Selection criteria of Sensors and Actuators		
3.0		**Embedded Software**	**09**	**CO3**
	3.1	Program Modelling concepts: DFG and CDFG		
	3.2	Real-time Operating system: - Need of RTOS in Embedded system software and comparison with GPOS		
	3.3	Task, Task states, Multi-tasking, Task scheduling, and Algorithms- Preemptive SJF, Round-Robin, Priority, Rate Monotonic Scheduling, Earliest Deadline First.		
	3.4	Inter-process communication: Message queues, Mailbox, Event timers. Task synchronization: Need, Issues - Deadlock, Race condition, live Lock, Solutions using Mutex, Semaphores. Shared data problem, Priority inversion		
		Self-learning: Finite State Machine.		
4.0		**Embedded Communication Protocols**	**06**	**CO4**
	3.1	Communication Interfaces: Comparative study of Serial Communication Interfaces (RS-232, RS-485), SPI, I2C, CAN, USB (v2.0), Bluetooth, Zig-Bee. (Frame formats of above protocols are not expected)		
	3.2	Examples on Parallel Communication, Serial Communication, Wireless Communication		
		Self-learning: Local Interconnect Network		
5.0		**Real Time Operating Systems [RTOS]**	**08**	**CO5**
	5.1	Introduction to RTOS. Operating system basics and Types of OS.		
	5.2	Tasks, Process and Threads		
	5.3	Multiprocessing and, Multitasking		
	5.4	Task scheduling, Threads, Process, Scheduling:- Putting them all together		
		Self-learning: RTOS case study: FreeRTOS		

6.0		**Design examples and case studies of program model and programming with RTOS**	**06**	**CO6**
	6.1	Digital Camera: -Introduction to simple digital camera, Requirements and specifications, Design using Microcontroller and Microcontroller and CCDPP		
	6.2	Automatic Chocolate Vending Machine		
	6.3	Adaptive Cruise Control in car		
		Self-learning: Drone controller		
		Total	**39**	

Text books:

1. Frank Vahid, and Tony Givargis, *Embedded System Design: A Unified Hardware/Software Introduction,* Wiley Publication,2002.
2. Raj Kamal, *Embedded Systems Architecture, Programming and design*, Tata MCgraw Hill Publication,4th Edition, 2020.
3. Iyer, Gupta, *Embedded real systems Programming*, TMH, 1st Edition, 2003
4. David Simon, *Embedded systems software primer*, Pearson ,2009
5. K.V.K.K. Prasad, *Embedded Real Time Systems: Concepts, Design & Programming*, Dreamtech Publication,1st Edition, 2005.
6. Joseph Yiu, *The Definitive Guide to ARM CORTEX-M3 & CORTEX-M4 Processors*, Elsevier, 2014, 3rd Edition.

References:

1. Jonathan W.Valvano, *Embedded Microcomputer Systems – Real Time Interfacing*, Publisher - Cengage Learning, 3rd Edition, 2012.
2. Andrew Sloss, Domnic Symes, Chris Wright, *ARM System Developers Guide Designing and Optimising System Software,* Elsevier, 2004.
3. Shibu K V, *Introduction to Embedded Systems*, Tata McGraw Hill Education Private Limited, New Delhi, 2009.

Online Resources:

1. Introduction to Embedded system by Prof. Indranil Sengupta ,NPTEL, IIT Embedded System
2. Introduction to RTOS onYoutube RTOS

Course Assessment:

ISE:

- To be conducted in any of these forms - Assignment/ Quiz/ Presentation/ Class Test/ Case study etc. of 15 marks and 5 marks of attendance.

MSE:

- To be conducted as written examination for 20 marks (on 50% syllabus).

End Semester Examination:

$ ESE of duration 03 hours is 80 marks and scaled to 60.

1. The question paper will comprise 03 questions.
2. Question1 (20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
3. Question 2 (40 marks): - Solve any 04 out of 06. All questions carry 10 marks each.
4. Question 3 (20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
5. All COs should be mapped as per the weightage in the syllabus.

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
ETPEC6012	Error Control Codes	03	--	--	03	--	--	03

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE$			
		ISE	MSE				
ETPEC6012	Error Control Codes	20	20	60	--	--	100

Course pre-requisite:

1. FEC101: Applied Mathematics I
2. ETC301: Applied Mathematics III
3. ETC501: Digital Communication

Program Outcomes Addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/Development of Solutions
4. PO5: Engineering tool usage
5. PO11: Lifelong Learning
6. PSO1: Achieve eminence in domains like signal processing, VLSI, embedded IoT, RF and microwave

Course Objectives:

1. To provide a foundational understanding of error control systems, including the need for error detection and correction in digital communication.
2. To familiarize students with various error detection techniques and introduce the principles and structure of block codes.
3. To introduce the concepts of block coding techniques for error correction.
4. To enable students to analyze and design linear block codes for reliable data transmission.
5. To enable students to analyze and design cyclic codes for reliable data transmission
6. To develop the ability to understand, implement, and evaluate convolutional codes and decoding algorithms for practical communication systems.

Course Outcomes:

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

1. Identify the need for error control in digital communication systems and explain the fundamental concepts of error control systems.
2. Apply various error detection techniques such as parity checks, checksums, and CRC to detect errors in digital data.
3. Analyze the structure and parameters of block codes and evaluate their error detection and correction capabilities.
4. Construct and analyze linear block codes using generator and parity-check matrices for data reliability.
5. Design and implement cyclic codes using generating polynomials and perform encoding and decoding operations.
6. Analyze convolutional codes and apply encoding and decoding algorithms such as Viterbi decoding for error correction.

Module No.	Unit No.	Topics	Hrs.	CO
1.0		**Introduction to Error Control Systems**	**06**	**CO1**
	1.1	Reasons for the occurrence of error in digital communication systems. Error detection code, error correction code, Forward Error Correction (FEC) system and Automatic Retransmission Query (ARQ) system. Types of ARQ: stop and wait, go-back-N and Selective Repeat.		
		Self-learning: Efficiency comparison between different ARQ techniques, Hybrid ARQ.		
2.0		**Error Detection Codes**	**06**	**CO2**
	2.1	Vertical Redundancy Check (VRC) code, Horizontal Redundancy Check (HRC) code, two-dimensional code, repetition code, Cyclic Redundancy Check (CRC) code, checksum code, burst error detection code.		
		Self-learning: Error detection in TCP/IP Network and Ethernet Network.		
3.0		**Introduction to Block Codes**	**03**	**CO3**
	3.1	Code rate, code efficiency, code redundancy, systematic and non-systematic codes, Hamming weight and minimum Hamming weight, Hamming distance and minimum Hamming distance, detection capability and correction capability, Hamming bound, perfect block code, linearity and cyclic properties, Singleton bound, maximum distance code, Hamming code.		
		Self-learning: Analyze detection and correction capabilities with different examples.		
4.0		**Linear Block Codes**	**08**	**CO4**
	4.1	Code Generation: Systematic linear block code generation, calculation of error detection and correction capabilities, implementation of encoder.		
	4.2	Code Detection: Syndrome test, decoding table, block diagram of a decoder, error detection and correction, implementation of decoder.		
	4.3	Extended and shortened Hamming codes, burst error correction code.		
		Self-learning: Design generator matrix for different linear block codes.		
5.0		**Cyclic Codes**	**10**	**CO5**
	5.1	Generator polynomials, non-systematic cyclic code generation, systematic cyclic code generation, equivalent generator matrix for a generator polynomial, implementation of encoder using shift registers.		
	5.2	Code detection: Syndrome test, decoding table, block diagram of a decoder, error detection and correction, implementation of decoder.		
	5.3	BCH codes, dual codes.		
		Self-learning: RS code and LDPC code.		
6.0		**Convolutional Codes**	**06**	**CO6**
	6.1	Code rate, code efficiency, code redundancy, constraint length, generator sequence, generator polynomial, impulse response, generator matrix,		
	6.2	Code generation using shift registers, time-domain method, transform-domain method and generator matrix.		
	6.3	State of the encoder, state transition table, state diagram, tree diagram, trellis diagram, encoding and decoding using the above diagrams.		
	6.4	Recursive Systematic Convolutional (RSC) code and turbo code.		
		Self-learning: Applications of convolutional code in mobile communication system.		
		Total	**39**	

Text books:

1. Jorge Castiñeira Moreira & Patrick G. Farrell, *Error Control Coding*, Wiley student edition, 2014.
2. Vera Pless, *Introduction to the Theory of Error-Correcting Codes*, Wiley Student Edition, Third Edition, 2004.
3. T L Singal, *Digital Communication*, Mc-Graw Hill, New Delhi, First Edition, 2015.
4. P Ramakrishna Rao, *Digital Communication*, Tata Mc-Graw Hill, New Delhi, First Edition,2011.

References:

1. H. Taub, D. Schlling, and G. Saha, *Principles of Communication Systems*, Tata Mc- Graw Hill, New Delhi, Third Edition, 2012.
2. Lathi B P, and Ding Z, *Modern Digital and Analog Communication Systems*, Oxford University Press, Fourth Edition, 2017.
3. Haykin Simon, *Digital Communications*, John Wiley and Sons, New Delhi, Fourth Edition, 2014.
4. Bernard Sklar, *Digital Communications: Fundamentals and Applications*, Pearson Education, second Edition, 2006.
5. Graham Wade, *Coding Techniques: An Introduction to Compression and error Control*, Palgrave, 2004.
6. Shu Lin & Daniel J. Costello Jr, *Error Control Coding*, Pearson India, Second Edition, 2010.

Online Resources:

1. An Introduction to Coding Theory (via Indian Institute of Technology Kanpur / NPTEL/ SWAYAM)
2. Error control coding: An introduction to linear block code (via SWAYAM / NPTEL)
3. Error control coding: An introduction to convolutional codes (via SWAYAM)
4. Error Control Coding – 525.707 (via Johns Hopkins University Engineering for Professionals)

Course Assessment:

ISE:

- To be conducted in any of these forms - Assignment/ Quiz/ Presentation/ Class Test/ Case study etc. of 20 marks
- ISE 20 marks= 05 marks for attendance + 15 marks for activities.

MSE:

- To be conducted as written examination for 20 marks (on 40% - 50% syllabus)

End Semester Examination:

$ ESE of duration 03 hours is 80 marks and scaled to 60.

1. The question paper will comprise 03 questions.
2. Question1 (20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
3. Question 2 (40 marks): - Solve any 04 out of 06. All questions carry 10 marks each.
4. Question 3 (20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
5. All COs should be mapped as per the weightage in the syllabus.

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
ETPEC6013	IT Infrastructure and Security	03	--	--	03	--	--	03

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE$			
		ISE	MSE				
ETPEC6013	IT Infrastructure and Security	20	20	60	--	--	100

Course pre-requisite:

1. ETC402: Principles of Communication Engineering

Program Outcomes Addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO11: Lifelong learning.
4. PO5: Engineering Tool Usages
5. PSO2: Become technocrats capable of working in multi-disciplinary fields.

Course Objectives:

1. To introduce fundamentals to IT Infrastructure and its Management.
2. To develop underlying principles of infrastructure security.
3. To explore software vulnerabilities and attacks.
4. To introduce the protection mechanisms for operating systems and database security.
5. To explore the security aspects of wireless network infrastructure and protocols.
6. To investigate the different attacks on Web Applications and Web services.

Course Outcomes:

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

1. Describe IT Infrastructure and its Management.
2. Compare methods of Information Security.
3. Analyze software vulnerabilities and attacks on databases and operating systems.
4. Illustrate the need for security protocols in the context of wireless communication.
5. Analyze the different attacks on Open Web Applications and Web services.
6. Interpret various security solutions for Cloud infrastructure.

Module No.	Unit No.	Topics	Hrs.	CO
1.0		**Overview of Networks and IT Infrastructure**	**09**	**CO1**
	1.1	Overview of OSI and TCP/ IP Networks, introduction to IP Addressing scheme, introduction to Networking Components		
	1.2	Information Technology, Design Issues of IT Organizations and IT Infrastructure, Information System Design Process, IT Infrastructure Management, Challenges in IT Infrastructure Management.		
		Self-learning: Determining Customers, Requirements, Security controls and safeguards, IT security Plans.		
2.0		**Introduction to Information Security**	**06**	**CO2**
	2.1	Cyber-attacks, Vulnerabilities, Defense Strategies and Techniques, Authentication Methods- Password, Token and Biometric, Access Control Policies and Models (DAC, MAC, BIBA, Bell La Padula)		
		Self-learning: Authentication and Access Control Services- RADIUS, TACACS, and TACACS+		
3.0		**Software Security**	**09**	**CO3**
	3.1	Software Vulnerabilities: Buffer Overflow, Format String, Cross-Site Scripting, SQL Injection, Malware: Viruses, Worms, Trojans, Logic Bomb, Bots, Rootkits		
	3.2	Operating System Security: Introduction to operating system security, system security planning, Application security, Linux/ Unix security, Windows, security, Security Maintenance.		
	3.3	Database Security: Database Security Requirements, Reliability and Integrity, Sensitive Data, Inference Attacks, Multilevel Database Security		
		Self-learning: Format String, File System Security (Windows and Linux OS).		
4.0		**Wireless Security**	**05**	**CO4**
	4.1	The need for Wireless Network Security, Attacks on Wireless Networks, Security services, WEP and WPA protocols, Mobile IP, Virtual Private Network (VPN): PPTP, L2TP, IPSec.		
		Self-learning: Network security and analysis tools like Wireshark, Cain and Abel, Aircrack.		
5.0		**Web Security**	**06**	**CO5**
	5.1	Introduction: Transport Protocol and Data Formats, Web Browser, Threat Model Authenticated Sessions: Cookie Poisoning, Cookies and Privacy, Making Ends Meet Code Origin Policies, Cross-Site Scripting: Cookie Stealing, Defending against XSS, Cross-Site Request Forgery, JavaScript Hijacking.		
		Self-learning: Penetration Testing tools like SQL Map, Wapiti		
6.0		**Cloud Security**	**04**	**CO6**
	6.1	Cloud Security Risks and Countermeasures, Data Protection in Cloud, Cloud Application Security, Cloud Identity and Access Management, Cloud Security as a Service.		
		Self-learning: Basics of security services like AWS		
		Total	**39**	

Text books:

1. Gupta, *IT Infrastructure & Its Management*, First Edition, Tata McGraw-Hill Education, 2009.
2. William Stallings, *Computer Security Principles and Practice,* Sixth Edition, Pearson Education, 2024.
3. Dieter Gollmann, *Computer Security,* Third Edition, Wiley Publications, 2011.
4. Forouzan, *Data Communications and Networking*, Fourth Edition, Mc Graw Hill Publication, 2017.
5. P. Nicopolitidis, M.S. Obaidat, G.I Papadimitriou, A.S Pomportsis, *Wireless Networks,*Wiley Publications, 2009.
6. Tim Mather, Subra Kumaraswamy, Shahed Latif, O'Riely *Cloud Security and Privacy: An Enterprise Prospective on Risks and Compliance*, Shroff Publishers and Distributers,2009.

References:

1. Charles P. Pfleeger, *Security in Computing,* Fifth Edition, Pearson Education, 2023.
2. Tim Boyle, *CCNA Security Study Guide,* Wiley Publications, 2010.
3. Matt Bishop, *Introduction to Computer Security,* Pearson, 2005
4. *Web Application Hackers Handbook* by Wiley,2011.
5. Dieter Gollman, *Computer Security,* Third Edition, Wiley, 2011.
6. Nina Godbole, Sunit Belapure, *Cyber Security,* Wiley India, New Delhi, 2011.

Online Resources:

1. NPTEL Course on Cyber Security and Privacy by Prof. Sajid K. Mathew, IIT Madras.
2. NPTEL Course on Ethical Hacking by Prof. Indranil Sengupta, IIT Kharagpur.
3. Coursera Course on Introduction to Cyber Security by Dr. Edward G. Amoroso.

Course Assessment:

ISE:

- To be conducted in any of these forms - Assignment/ Quiz/ Presentation/ Class Test/ Case study etc. of 20 marks
- ISE 20 marks= 05 marks for attendance + 15 marks for activities.

MSE:

- To be conducted as written examination for 20 marks (on 40% - 50% syllabus)

End Semester Examination:

$ ESE of duration 03 hours is 80 marks and scaled to 60.

1. The question paper will comprise 03 questions.
2. Question1 (20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
3. Question 2 (40 marks): - Solve any 04 out of 06. All questions carry 10 marks each.
4. Question 3 (20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
5. All COs should be mapped as per the weightage in the syllabus.

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
ETPEC6014	Database Management Systems	03	--	--	03	--	--	03

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE$			
		ISE	MSE				
ETPEC6014	Database Management Systems	20	20	60	--	--	100

Course pre-requisite:

1. ETPEC5014: Data structures and Algorithms

Program Outcomes Addressed:

1. PO1: Engineering Knowledge.
2. PO2: Problem Analysis.
3. PO3: Design and Development solution.
4. PO5: Modern Tool usage
5. PO11: Life-Long Learning.
6. PSO2: Become technocrats capable of working in multi-disciplinary fields.

Course Objectives:

1. To understand the basics of database systems.
2. To develop an entity-relationship data model and its mapping to a relational model
3. To learn relational algebra and formulate SQL queries.
4. To apply normalization techniques to normalize the database.
5. To understand the concept of transactions, concurrency control, and recovery techniques
6. To learn and explore recent databases and their applications.

Course Outcomes:

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

1. Identify the purpose of the database management system and its operational details.
2. Develop data models using ER diagrams, relational schemas and relational algebra.
3. Apply SQL queries to the given database.
4. Apply normalization techniques for relational database design.
5. Describe the concepts of transaction management, concurrency control and database recovery.
6. Describe the fundamentals of recent databases and their uses.

Module No.	Unit No.	Topics	Hrs.	CO
1.0		**Introduction to Database Concepts and Data modeling**	**08**	**CO1**
	1.1	Introduction, characteristics of databases, file system vs. database system, data abstraction and data independence, DBMS system architecture, and applications of databases.		
	1.2	The Entity-Relationship (ER) model, Entity types: weak and strong entity sets, entity sets, types of attributes, keys, and relationships. Constraints, cardinality and participation, Extended Entity Relationship (EER) Model: generalization, specialization and aggregation.		
		Self-learning: Database storage structures		
2.0		**Relational Model and Relational Algebra**	**05**	**CO2**
	2.1	Introduction to the relational model, relational schema. Mapping the ER and EER models to the relational model.		
	2.2	Relational algebra - operators and algebra queries.		
		Self-learning: Relational calculus		
3.0		**Structured Query Language (SQL)**	**08**	**CO3**
	3.1	Overview of SQL, data definition commands, integrity constraints: key constraints, domain constraints, referential integrity, check constraints		
	3.2	Data Manipulation commands, data control commands, set and string operations, aggregate functions, group by, having views in SQL, joins, nested and complex queries.		
		Self-learning: Stored procedures, Introduction to PL/SQL		
4.0		**Database Normalization**	**06**	**CO4**
	4.1	Pitfalls in relational database designs, concept of normalization		
	4.2	Function Dependencies, first normal form, 2NF, 3NF, BCNF, 4NF.		
		Self-learning: 5NF		
5.0		**Transactions Management, Concurrency Control and Recovery**	**08**	**CO5**
	5.1	Transaction concept, transaction states, ACID properties, transaction control commands, concurrent executions, serializability-Conflict and View.		
	5.2	Concurrency Control: lock-based, timestamp-based protocols, recovery system: log-based recovery.		
		Self-learning: Deadlock		
6.0		**Introduction to Emerging databases**	**04**	**CO6**
	6.1	Limitations of conventional databases, multimedia databases: data types, contents of multimedia databases		
	6.2	Cloud databases: Introduction, Design Steps		
	6.3	Distributed databases: Types, storage methods		
		Self-learning: Object-oriented database, NoSQL databases, vector DB		
		Total	**39**	

Text Books:

1. Korth, Silberchatz, Sudarshan, *Database System Concepts,* 7th Edition, McGraw Hill, 2019.
2. Elmasri and Navathe, *Fundamentals of Database Systems*, 7th Edition, Pearson Education, 2016
3. Raghu Ramakrishnan and Johannes Gehrke, *Database Management Systems*,3rd Edition, TMH (McGraw-Hill), 2002.

Reference Books:

1. Peter Rob and Carlos Coronel, *Database Systems: Design, Implementation, and Management*, 13th Edition, Thomson Learning, 2019.
2. Dr. P.S. Deshpande, *SQL and PL/SQL for Oracle 10g, Black Book*, Dream Tech Press, 1 st edition,2007.
3. G. K. Gupta, *Database Management Systems*, McGraw Hill, 1 st edition,2012.

Online Resources:

1. NPTEL : Database Management Systems, Prof. Aditya Kumar Gupta https://swayam.gov.in/nd1_noc19_cs46/preview
2. Swayam: Database Management System https://www.classcentral.com/course/swayam-database-management-system-9914

Course Assessment:

ISE:

- To be conducted in any of these forms - Assignment/ Quiz/ Presentation/ Class Test/ Case study etc. of 20 marks
- ISE 20 marks= 05 marks for attendance + 15 marks for activities.

MSE:

- To be conducted as written examination for 20 marks (on 40% - 50% syllabus)

End Semester Examination:

$ ESE of duration 03 hours is 80 marks and scaled to 60.

1. The question paper will comprise 03 questions.
2. Question1 (20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
3. Question 2 (40 marks): - Solve any 04 out of 06. All questions carry 10 marks each.
4. Question 3 (20 marks): - Solve any 04 out of 06. All questions carry 05 marks each.
5. All COs should be mapped as per the weightage in the syllabus.

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
ETL601	Digital Signal and Image Processing Lab	--	02	--	--	01	--	01

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE			
		ISE	MSE				
ETL601	Digital Signal and Image Processing Lab	--	--	--	25	--	25

Course pre-requisite:

1. ETL303: Skill Lab - Python Programming

Program Outcomes Addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/Development of solutions
4. PO5: Engineering tool usage
5. PO7: Ethics
6. PO8: Individual and Collaborative teamwork
7. PSO1: Achieve eminence in domains like signal processing, VLSI, embedded IOT, RF and microwave.

Lab Objectives:

1. To demonstrate DFT and FFT fundamentals and apply them to convolution and system analysis.
2. To design FIR and IIR filters
3. To implement image compression transforms.
4. To execute basic image fundamentals and point-processing operations.
5. To perform spatial and frequency-domain image enhancement.
6. To apply segmentation and carry out morphological operations.

Lab Outcomes:

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

1. Demonstrate DFT and FFT fundamentals and apply them to convolution and system analysis.
2. Design FIR and IIR filters.
3. Implement various image compression transforms.
4. Perform Image Enhancement using spatial and frequency domain processing
5. Implement edge detection and segmentation methods on images.
6. Perform morphological operations on the images.

Suggested List of Experiments:		
Sr. No.	**Title of Experiments**	**LO**
1	**Compute the Discrete Fourier Transform and Inverse DFT of 1D signals:** Implement the Discrete Fourier Transform (DFT) and Inverse DFT for a given 1-D signal by a. computing amplitude and phase spectra, b. reconstructing the original signal using IDFT, c. verifying perfect reconstruction, and d. analyzing the effect of signal length and sampling rate on the frequency spectrum.	LO1
2	**Perform 2D–DFT and 2D–IDFT on a grayscale image and display the magnitude spectrum:** Compute the 2-D Discrete Fourier Transform (DFT) of a grayscale image by a. displaying the magnitude and phase spectra, b. reconstructing the image using the 2-D Inverse DFT, c. evaluating the reconstruction quality, and d. studying the relationship between frequency components and image features.	LO1
3	**Implement linear and circular convolution using DFT and compare results with time-domain convolution:** Perform linear and circular convolution of two 1-D signals using the DFT by a. computing convolution in the frequency domain, b. comparing the results with time-domain convolution, c. analyzing the conditions under which circular convolution approximates linear convolution, and d. validating the role of zero-padding for accurate linear convolution.	LO1
4	**Implement Radix-2 DIT–FFT for N-point signals and perform basic spectral analysis:** Implement the Radix-2 Decimation-in-Time Fast Fourier Transform (DIT-FFT) for N-point signals by a. performing spectral analysis of test signals, b. comparing execution time with direct DFT computation, and c. demonstrating the reduction in computational complexity achieved using FFT.	LO1
5	**Frequency-Selective Behavior of LTI Systems** a. Demonstrate LTI systems acting as low-pass, high-pass, band-pass, band-stop (notch), comb, and all-pass filters. b. Analyze magnitude and phase responses.	LO2
6	**Mapping from s-Plane to z-Plane** a. Study impulse invariant and bilinear transformation techniques. b. Compare pole–zero locations in the s-plane and z-plane. c. Analyze frequency warping in bilinear transformation.	LO2
7	**Design of Butterworth IIR Digital Filters** a. Design a low-pass Butterworth IIR filter from an analog prototype. b. Compare frequency responses.	LO2
8	**Zeros of Linear Phase FIR Filters** a. Determine zero locations for linear-phase FIR filters. b. Identify minimum phase, maximum phase, and mixed phase systems. c. Analyze stability and causality.	LO2
9	**FIR Filter Design Using Window Techniques** a. Design FIR filters using: Rectangular, Hamming, Hanning, Blackman b. Compare main-lobe width and side-lobe attenuation.	LO2

11	**Apply 2D–DCT for image compression and reconstruct the image using limited coefficients:** Apply the 2-D Discrete Cosine Transform (DCT) to a grayscale image for compression by a. retaining a limited number of DCT coefficients, b. reconstructing the image using inverse DCT, and c. analyzing the trade-off between compression ratio and reconstructed image quality	LO3
12	**Perform 2D–DWT (or WHT) on an image and reconstruct it using inverse transform:** Perform the 2-D Discrete Wavelet Transform (DWT) or 2-D Walsh–Hadamard Transform (WHT) on an input image by a. obtaining approximation and detail subbands, b. reconstructing the image using the inverse transform, and c. evaluating reconstruction quality while analyzing the role of multi-resolution representation in image compression and enhancement.	LO3
13	**Make use of Image negative, gray level Slicing and Thresholding on to a given image:** Apply image negative transformation, gray-level slicing (with and without background), and global/adaptive thresholding to a grayscale image by a. performing each transformation, b. observing their effects on image appearance, and c. evaluating how these techniques enhance feature visibility and interpretability.	LO4
14	**Make use of Contrast Stretching, Dynamic range compression and Bit plane Slicing to a given image:** Perform intensity transformations on a grayscale image by a. applying contrast stretching and dynamic range compression, b. extracting all bit planes using bit-plane slicing, and c. analyzing their contribution to visual appearance and enhancement of low-contrast images.	LO4
15	**Perform histogram equalization and histogram specification on a grayscale image:** Compute and enhance the histogram of a grayscale image by a. performing histogram equalization, b. applying histogram specification using a reference histogram, and c. comparing the original and processed images in terms of contrast and visibility.	LO4
16	**Apply spatial filters (averaging, median, Laplacian, unsharp masking) for image smoothing and sharpening:** Apply spatial filtering to a grayscale image by a. performing averaging, median, Laplacian, and unsharp masking filters, b. comparing their effects on noise reduction and edge enhancement, and c. discussing the trade-off between smoothing and detail preservation.	LO4

17	**Apply Ideal, Butterworth, and Gaussian low-pass and high-pass frequency-domain filters using 2D–DFT:** Design and implement Ideal, Butterworth, and Gaussian low-pass and high-pass filters by a. applying them in the frequency domain using the 2-D DFT of an image, b. reconstructing the filtered images using IDFT, and c. analyzing their effects on edge sharpness, smoothing, and artifacts.	LO4
18	**Implement edge detection using Sobel, Prewitt, and Roberts operators:** Implement edge detection on images by a. applying Sobel, Prewitt, and Roberts operators, b. extracting and analyzing edge maps, and c. comparing their sensitivity to noise, edge sharpness, and directionality on both noisy and clean images	LO5
19	**Perform region-based segmentation and apply morphological operations such as erosion, dilation, opening, closing, boundary extraction, and hole filling:** Perform region-based image segmentation by a. applying techniques like region growing or threshold-based labeling, b. using morphological operations such as erosion, dilation, opening, closing, boundary extraction, and hole filling on the segmented image c. analyzing how these operations refine and improve segmented regions	LO5, LO6

Software Tools:
Open-source simulation tools: SCILAB, Python

Term Work:
The term work should include at least 12 experiments. Term work will be assessed as Continuous Internal Assessment Practical (CIAP).

Term work Marks:
25 Marks (Total Marks) = 20 Marks (Experiment) + 05 Marks (Attendance)
The final certification and acceptance of term work ensure satisfactory performance of laboratory work and minimum passing marks in term work.

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
ETL602	Mobile Communication and Digital VLSI Lab	--	02	--	--	01	--	01

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE			
		ISE	MSE				
ETL602	Mobile Communication and Digital VLSI Lab	--	--	--	25	25	50

Course pre-requisite:

1. FEL203: Digital System Design Lab
2. ETL302: Electronic Devices and Circuits Lab
3. ETL501: Principles of Communication Engineering Lab

Program Outcomes Addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design/Development of solutions
4. PO5: Engineering tool usage
5. PO7: Ethics
6. PO8: Individual and Collaborative teamwork
7. PSO1: Achieve eminence in domains like signal processing, VLSI, embedded IOT, RF and microwave.

Lab Objectives:

1. To explain mobile communication system behavior using simulation results.
2. To illustrate multiple access techniques and physical-layer features of 4G/LTE and 5G systems.
3. To demonstrate 4G/LTE and 5G communication techniques using software tools.
4. To illustrate CMOS combinational and sequential circuits using VLSI tools.
5. To demonstrate CMOS circuit performance at schematic and layout levels.
6. To introduce RTL-based digital designs using EDA platforms.

Lab Outcomes:

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

1. Analyze mobile communication systems using simulation tools.
2. Analyze and assess multiple access schemes adopted in 4G/LTE and 5G technologies.
3. Apply selected 4G/LTE and 5G communication techniques and interpret their results.
4. Analyze CMOS-based combinational and sequential circuits using VLSI tools.
5. Design CMOS circuits at schematic and layout levels with performance evaluation.
6. Develop RTL based digital designs using standard EDA platforms.

Suggested List of Experiments: Mobile Communication		
Sr. No.	**Title of Experiments**	**LO**
1	**Simulation of the effect of cluster size on system capacity.b) Simulation of the effect of cluster size on S/I ratio.** a. Model hexagonal cell layout and implement reuse patterns for chosen N. b. Compute channels available per cell and maximum supported simultaneous calls per cell. c. Calculate system capacity (calls per km²) for each N. d. Plot capacity vs. cluster size NNN. e. Discuss trade-offs between capacity and interference (link to S/I) f. Derive S/I formula for iii interfering co-channel cells (use standard K = 6 first tier). g. For each N, compute co-channel reuse distance D and S/I for mobile at cell centre and at worst-case point (cell boundary). h. Tabulate and plot S/I (dB) vs. N. i. Interpret results and relate S/I to capacity decisions	LO1
2	**Simulation of the effect of sectorization of cluster size on S/I ratio.** a. Model sector antenna gains and orientation for 3- and 6-sector cases. b. Compute S/I at cell-edge and cell-centre for omni and sectorized layouts. c. Evaluate equivalent capacity increase from S/I improvement (e.g., smaller reuse N or higher user density). d. Present plots and discussion	LO1
3	**Study of mobile radio propagation effects using Scilab** a. Implement path-loss models b. Calculate received power and path loss	LO1
4	**Study how call blocking probability varies as the load on a GSM network is continuously increased.** a. Simulate a GSM sector/cell b. Study how call blocking probability varies as offered traffic load (Erlangs) increases. c. Compare performance for different numbers of channels	LO1
5	**PN Sequence Generation (CDMA) using Scilab.** a. Implement linear feedback shift register (LFSR) logic in Scilab b. Generate maximal-length PN sequences suitable for CDMA spreading. c. Demonstrate spreading of a short data stream.	LO2
6	**Study how the throughput of LTE network varies as the distance between the ENB (Evolved node-B) and UE (User Equipment) is increased.** a. Simulate an LTE cell and measure how user throughput varies as the distance between the eNodeB and UE increases (path loss effect). b. For each distance, measure SNR, selected MCS, and throughput (per user and average). c. Plot average throughput vs distance.	LO2
7	**Study how the throughput of LTE network varies as the Channel bandwidth changes in the ENB (Evolved node B).** a. Investigate how cell throughput scales with LTE channel bandwidth. b. For a fixed number of users and traffic model, simulate and plot throughput vs bandwidth and analyze spectral efficiency.	LO3

8	**To analyze how the operational behavior of Incumbent (Primary User) affects the throughput of the CR CPE (Secondary User).** a. In a cognitive radio (CR) scenario, analyze how the temporal behavior of the incumbent (primary user) impacts the achievable throughput of a CR customer premises equipment (CPE) that opportunistically uses spectrum. b. Plot secondary throughput vs primary occupancy metrics; discuss sensing overhead and collision probability.	LO3
9	**To analyze how the allocation of frequency spectrum to the Incumbent (Primary) and CR CPE (Secondary User) affects the throughput of the CR CPE (Secondary User).** a. Evaluate how different spectrum-allocation policies between primary incumbents and CR CPEs influence the throughput and QoS of the CR CPE. b. Compare metrics: CR throughput, primary impact (interference/collisions), spectrum utilization.	LO3
10	**Configuration of wireless heterogeneous network using a simulation environment.** a. Configure a heterogeneous wireless network b. Generate traffic from mobile clients and show connectivity, throughput, and failover/offload behavior.	LO4
11	**Study how number of channels and call blocking probability with voice activity factor of CDMA network.** a. Compute the theoretical maximum number of simultaneous users under synchronous/asynchronous CDMA assumptions. b. Incorporate voice activity factor into offered load and compute blocking (use appropriate blocking model or simulation). c. Plot blocking probability vs number of users / channels for different voice activity factors	LO3
12	**To plot channel capacity versus SNR for different MIMO systems.** a. For single-input single-output (SISO) and multiple-input multiple-output (MIMO) configurations (e.g., 1×1, 2×2, 4×4), b. Plot theoretical channel capacity vs. SNR (in dB). Consider both rich-scattering (independent channels) and correlated channel scenarios. c. Analyze capacity gains from MIMO and impact of correlation and antenna spacing.	LO3
13	**Throughput vs. Bandwidth for 5G New Radio (eMBB)** a. Simulate a single cell 5G NR downlink and measure user throughput as system bandwidth and numerology change. b. Evaluate spectral efficiency and aggregate cell throughput for different subcarrier spacings (15/30/60/120 kHz) and bandwidths (e.g., 20, 50, 100, 400 MHz).	LO3

Suggested List of Experiments: Digital VLSI		
Sr. No.	**Title of Experiments**	**LO**
1	**Plot Transfer and output characteristics of NMOS and PMOS** a. Simulate the NMOS and PMOS devices to obtain their transfer (Id–Vgs) and output (Id–Vds) characteristics. b. Analyze threshold voltage, saturation region, triode region, body effect, channel-length modulation, and compare the behavior of both devices under varying bias conditions.	LO4
2	**CMOS inverter design; static and transient simulation with varying aspect ratios** a. Design a CMOS inverter using different width-to-length (W/L) ratios for NMOS and PMOS. b. Perform DC static simulations to determine switching threshold, noise margins, and power dissipation. c. Conduct transient simulations to measure rise time, fall time, and propagation delays for multiple aspect ratios.	LO4
3	**VTC of NAND/NOR, noise margins, equivalent-inverter validation**. a. Obtain the Voltage Transfer Characteristics (VTC) of CMOS NAND and NOR gates. b. Extract noise margins, switching threshold, and logic-level degradation. Validate each gate's switching behavior by comparing it to an equivalent CMOS inverter model. **Transient analysis of NAND/NOR: delays, rise/fall times** a. Simulate the dynamic switching behavior of CMOS NAND and NOR gates. b. Measure propagation delays (t_{pHL} and t_{pLH}), rise time, fall time, and loading effects. c. Analyze the influence of fan-out, transistor sizing, and input combinations on timing performance.	LO4
4	**Implement logic equation using different design styles** a. Implement a given Boolean logic function using multiple VLSI design methodologies such as static CMOS, dynamic CMOS, pass-transistor logic, transmission-gate logic, and pseudo-NMOS. b. Compare area, power consumption, delay, and signal integrity across design styles.	LO4
5	**Implementation of Combinational and Sequential circuit using various design styles** a. Design and simulate different combinational and sequential circuits ex: Adder, Decoder, Multiplexer, Flip Flop etc b. Evaluate setup time, hold time, clock-to-Q delay, and power consumption.	LO4
6	**Layout design and simulation of CMOS inverter** a. Draw the physical layout of a CMOS inverter adhering to design rules (DRC). Extract the layout for LVS verification and perform post-layout simulations.	LO5
7	**Layout design and simulation of CMOS NAND and NOR** a. Draw and verify the physical layouts of 2-input CMOS NAND and NOR gates. Perform DRC, LVS, and post-layout extraction. b. Simulate the designs to observe the impact of parasitic capacitances on switching times and delays.	LO5
8	**NAND-based and NOR-based ROM array.** a. Design and simulate a small ROM array using NAND and NOR logic-based storage architectures. b. Implement memory decoding, word-line and bit-line operations, and verify stored bit patterns. c. Compare power, delay, and area between NAND and NOR ROM structures.	LO5

9	**Performance analysis of 1T and 3T DRAM cells**. a. Model and simulate 1T and 3T DRAM cell architectures. b. Analyze read and write operations, charge leakage, refresh requirements, and sense amplifier behavior. c. Compare density, speed, and data retention characteristics.	LO5
10	**Performance analysis of 6T SRAM Cell.** a. Design and simulate a standard 6T SRAM cell. b. Perform read stability (read margin), write ability (write margin), hold stability (static noise margin), and access time analysis. c. Investigate the impact of sizing ratios and bit-line capacitances on performance.	LO4
11	**RTL design of Soda Dispenser FSM.** a. Develop the Register Transfer Level (RTL) architecture for a soda-dispenser finite state machine (FSM). b. Write RTL code, simulate state transitions, test for each input scenario, and verify correct dispensing logic. c. Synthesize and analyze timing and area.	LO6
12	**RTL design of FIR filter** a. Implement a Finite Impulse Response (FIR) digital filter at RTL using behavioral and structural coding techniques. b. Simulate filter functionality, verify frequency response, and evaluate hardware resource usage. c. Optionally perform synthesis and timing analysis.	LO6

This is only a suggested list. As per availability, one can modify the experiment list.

Link for virtual lab: http://www.vlsi-iitg.vlabs.ac.in

Software Tools:
Before starting the experiments, there should be one session on the study of development tools. Computation/ Simulation based experiments are also encouraged**.**

Term Work:
The term work shall consist of at least 12 laboratory experiments, comprising 6 experiments in Mobile Communication and 6 experiments in DVLSI. Term work will be assessed as Continuous Internal Assessment Practical (CIAP).

Term work Marks:
25 Marks (Total Marks) = 20 Marks (Experiment) + 05 Marks (Attendance)
The final certification and acceptance of term work ensure satisfactory performance of laboratory work and minimum passing marks in term work.

Practical Exam: (2 hours/ 25 Marks)
End-semester Practical and oral exam will be held based on the above syllabus and will be conducted as End Semester Examination Practical (ESEP).

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
ETL603	Skill Lab - Cloud Computing	--	02*+ 02	--	--	02	--	02

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE			
		ISE	MSE				
ETL603	Skill Lab - Cloud Computing	--	--	--	25	25	50

Course pre-requisite:

1. ETL403: Skill Lab - Linux
2. ETC502: Computer Communication Networks
3. ETL502: Computer Communication Networks

Program Outcomes Addressed:

1. PO1: Engineering knowledge
2. PO2: Problem analysis
3. PO3: Design and development of solutions
4. PO5: Modern tool usage
5. PO9: Individual and teamwork
6. PO11: Lifelong learning
7. PSO2: Become technocrats capable of working in multi-disciplinary fields

Lab Objectives:

1. To conceptualize cloud computing fundamentals.
2. To make students familiar with key concepts of virtualization.
3. To familiarize students with different cloud service models, including IaaS, PaaS, and SaaS,
4. To provide students with an understanding of Security as a Service (SECaaS)
5. To acquaint students with open cloud platforms, containerization technologies, and orchestration.

Lab Outcomes:

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

1. Implement different types of virtualization techniques.
2. Analyze various cloud computing service models and implement them to solve the given problems.
3. Identify major security issues in the cloud and provide appropriate security solutions.
4. Evaluate multiple open cloud platforms and justify the selection of an optimal platform for specific application needs.
5. Implement the concept of containerization and orchestration.
6. Implement Server-less architecture and configure workflows.

Module No.	Unit No.	Topics	Hrs.	LO
1		**Introduction to Cloud Computing**	**03**	**LO1**
	1.1	Definition of Cloud Computing, Need for Cloud computing, Characteristics, NIST model		
	1.2	Cloud deployment models (Public, Private, Hybrid, Community) and Service Models: IaaS, PaaS, and SaaS.		
	1.3	Advantages and Disadvantages of Cloud Computing.		
		Self-Learning: Compare cloud vs traditional computing.		
2		**Virtualization and Hypervisors**	**04**	**LO2**
	2.1	Introduction and benefits of virtualization, Virtualization Structures and Implementation Levels, Virtual Machine Monitor (VMM).		
	2.2	Hypervisors —Type I, II (Xen, KVM, VMware ESXi, Hyper-V), Virtualization Mechanisms and Tools, Hosted vs Bare Metal Hypervisors.		
		Self-Learning: Virtualization vs Containerization.		
3		**Amazon Core Services**	**08**	**LO3**
	3.1	Introduction to the AWS Cloud. **Compute service:** Introduction to EC2, Instance Types, instance lifecycle, Auto Scaling, Load Balancing.		
	3.2	**Storage service:** Introduction to S3, working with Buckets, setting bucket security, bucket properties, working with Elastic Block Store (EBS) Volumes, and Object Storage Vs Block Storage.		
	3.3	**Network as a Service:** Introduction to virtual private cloud (VPC), Subnets, Elastic Network Interfaces, Internet Gateways, Route Tables, Security Groups, and Network ACLs.		
	3.4	**Database as a Service:** Introduction to Amazon Relational Database Service (RDS), Database Engines, Non-relational (No-SQL) Databases, Types of Non-relational Databases, and their features.		
	3.5	**Deployment and Management Services:** Amazon Elastic Beanstalk		
		Self-Learning: Comparison of AWS services with other cloud service platforms. Selection criteria for cloud vendors.		
4		**Cloud Security and Identity Management**	**04**	**LO4**
	4.1	**Security service:** AWS Identity and Access Management (IAM). **Amazon Cognito:** Provides user authentication, authorization, and user management for web and mobile applications via user pools. **AWS Key Management Service (KMS):** A managed service for creating, storing, and controlling encryption keys.		
	4.2	AAA Administration for Clouds - AAA model, SSO for Clouds, Authentication management, and Authorization management in clouds.		
		Self-Learning: Cloud Security in AWS.		
5		**Containerization and Orchestration**	**03**	**LO5**
	5.1	**Containerization using Docker -** Docker containerization concepts, image building, running containers, Docker architecture		
	5.2	**Kubernetes -** Kubernetes orchestration**,** Kubernetes architecture, steps to deploy a Kubernetes Cluster on local systems, deploy applications on Kubernetes, and create a Service in Kubernetes		
		Self- Learning: Basics of CI/CD pipeline.		

6		Serverless and ML on Cloud	04	LO6
	6.1	**Serverless Computing:** Basics of Serverless Computing, Working with Serverless environment, Introduction to serverless events and functions, AWS Lambda. **Application services:** AWS Simple Notification Service (SNS), Simple Queue Service (SQS), and Simple Email Service (SES).		
	6.2	**Machine Learning with SageMaker:** Introduction to SageMaker Studio, preparing datasets, and training ML models using built-in algorithms.		
		Self-Learning: Explore real-world use cases and case studies on sustainability and green cloud practices.		

Suggested List of Experiments:		
Sr. No.	**Title of Experiments**	**LO**
1	**Introduction to Virtualization** To study and implement Hosted Virtualization using Virtual Box and KVM. a. Create and run Virtual machines inside hosted hypervisors like Virtual Box and KVM with their comparison based on various virtualization parameters. b. Understand concept of Virtualization along with their types, structures and mechanisms	LO1
2	**To study and implement Bare Metal Hypervisor using Xen Server** To study and implement Bare Metal Hypervisor using Xen Server. a. Install Xen Hypervisor and related packages b. Configure GRUB to boot Xen c. Launch Xen Manager and create/manage VMs d. Understand Xen architecture and components	LO1
3	**Introduction to Identity and Access management** To understand and manage Identity and Access Management (IAM) by exploring users, groups, and policies. a. Explore IAM Users and Groups b. Inspect IAM policies applied to groups c. Add users to groups d. Locate IAM sign-in URL e. Experiment with policy effects	LO3
4	**Introduction to cloud compute service** To understand and manage compute instances. a. Launch compute instance b. Configure security groups c. Monitor and resize compute instance	LO2
5	**To work with Block Storage services** To manage Block Storage volumes. a. Create and attach Block Storage volume b. Format and mount volume c. Create snapshot and restore volume	LO2
6	**Scale and Load Balance Your Architecture** To implement Load Balancing and Auto Scaling. a. Create load balancer b. Configure Auto Scaling group	LO2

	c. Monitor performance using CloudWatch	
7	**Build Virtual private Cloud and Launch a Web Server** To design and deploy a custom VPC and launch compute instance. a. Create VPC and subnets b. Configure security group c. Launch compute instance in VPC	LO2
8	**Introduction to Cloud Object Storage Service** To learn basic features of Object Storage Service. a. Create storage bucket b. Upload objects c. Manage permissions and bucket policies	LO2
9	**Build Your DB Server and Interact with Your DB Using an App** To deploy and configure Relational Database Service (RDS). a. Launch RDS instance b. Configure DB connectivity c. Interact with DB using web app	LO2
10	**To secure Applications by Using Amazon Cognito** To deploy and configure Amazon RDS. a. Create user pool b. Configure identity pool c. Integrate authentication in app	LO2
11	**To encrypt Data at Rest by Using AWS Encryption Options** To secure applications using Amazon Cognito. a. Review default encryption b. Create KMS key c. Encrypt EBS and S3 data	LO3
12	**Automating Infrastructure Deployment with Cloud Formation** To automate deployment using Cloud Formation. a. Deploy VPC and app layers b. Explore templates in Designer c. Delete stack with retention policy	LO3
13	**Building Decoupled Applications by Using Amazon SQS** To build decoupled architecture using SQS and SNS. a. Configure S3 events to SNS b. Subscribe SQS to SNS c. Implement message polling	LO4
14	**Implementing a Serverless Architecture on Cloud** To design and implement serverless architecture using function as service. a. Invoke FaaS from object storage/ DB b. Configure notifications using notification service c. Build serverless workflow	LO5
15	**Installation and Configuration of OpenStack** To install and configure OpenStack using Devstack. a. Understand OpenStack architecture b. Install OpenStack using DevStack c. Access Horizon dashboard and launch instances	LO5
16	**To study and Implement Containerization using Docker** To know the basic differences between Virtual machine and Container. a. Demonstrate creating, finding, building, installing, and running containers b. Work with Linux/Windows application containers on local or cloud platform	LO6
17	**To study and implement container orchestration using Kubernetes**	LO6

	To understand steps to deploy Kubernetes Cluster and manage applications. a. Deploy Kubernetes Cluster on local systems b. Deploy applications on Kubernetes c. Create a Service in Kubernetes d. Develop Kubernetes configuration files in YAML e. Create a deployment in Kubernetes using YAML	
18	**To Train a Machine Learning Model using Cloud ML Services.** To train a machine learning model using Cloud ML Services by applying the XGBoost algorithm on a biomechanical vertebral column dataset. a. Split data into training, validation, and test datasets b. Train an XGBoost model in Cloud ML Services	LO6
19	**To develop Machine Learning Pipeline with Cloud ML Services** To deploy a trained machine learning model using Cloud ML Services, perform predictions, and execute batch transformations on the test dataset. a. Deploy a machine learning model b. Use the test dataset to perform a batch transformation with the model	LO6

Textbooks

1. Rajkumar Buyya, Christian Vecchiola, S. Thamarai Selvi, *Mastering Cloud Computing*, McGraw Hill Education, First Edition, 1st July 2017.
2. Srinivasan, J. Suresh, *Cloud Computing: A Practical Approach for Learning and Implementation*, Pearson, First Edition, 1st January 2014.
3. Ronald L. Krutz, Russell Dean Vines, *Cloud Security: A Comprehensive Guide to Secure Cloud Computing*, Wiley & Sons, First Edition.
4. Barrie Sosinsky, Cloud *Computing Bible*, Wiley Publishing, First Edition, 11th January 2011.

Reference books

1. Kailash Jayaswal, Jagannath Kallakurchi, Donald J. Houde, Deven Shah, *Cloud Computing Black Book,* Dreamtech Press, Second Edition, 1st January 2014.
2. Michael Wittig, Andreas Wittig, *Amazon Web Services in sAction*, Manning Publisher, Second Edition.
3. Arora Pankaj, Raj Biyani, Salil Dave, *To the cloud: Cloud powering an Enterprise*, Tata Mc Graw Hill Education, First Edition, 20th January 2012.
4. Kai Hwang, *Distributed and Cloud Computing: From Parallel Processing to the Internet of Things,* Morgan Kaufmann Publishers Inc, First Edition, 22nd November 2011.

Term Work:

The term work should include 12 experiments from the list. The experiments can also be performed using Microsoft Azure and Google Cloud platforms for similar kinds of services. Term work will be assessed as Continuous Internal Assessment Practical (CIAP).

Term work Marks:

25 Marks (Total Marks) = 20 Marks (Experiment) + 05 Marks (Attendance)

The final certification and acceptance of term work ensure satisfactory performance of laboratory work and minimum passing marks in term work.

Practical Exam: (2 hours/ 25 Marks)

End-semester Practical / oral exam will be held based on the above syllabus and will be conducted as End Semester Examination Practical (ESEP).

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
MDML6012	Natural Language Processing Lab	--	02	--	--	01	--	01

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE			
		ISE	MSE				
MDML6012	Natural Language Processing Lab	--	--	--	25	--	25

Course pre-requisite:

1. ETL303: Skill Lab - Python Programming

Program Outcomes Addressed:

1. PO1: Engineering Knowledge
2. PO2: Problem Analysis
3. PO3: Design/Development of Solutions
4. PO4: Conduct Investigations of Complex Problems
5. PO5: Engineering Tool Usage
6. PO11: Life-Long Learning

Lab Objectives:

1. To understand text preprocessing techniques for real-world NLP tasks.
2. To familiarize with linguistic analysis through morphology, N-grams, and chunking.
3. To build statistical analysis for N-grams and parsing.
4. To understand semantic analysis and document similarity techniques
5. To learn NLP systems using standard classification techniques.
6. To understand large language models for understanding architectural variations.

Lab Outcomes:

Upon completion of this course, Learners will be able to:

1. Apply various text processing techniques for real-world NLP tasks..
2. Analyze linguistic structures using morphological processing, N- grams, and chunking techniques.
3. Develop statistical and neural language models such as POS tagging, HMMs, and Pasers.
4. Use TF-IDF and cosine similarity to extract semantics and document distances
5. Analyze the performance of modern NLP models including NER, and BERT classification.
6. Compare outputs and capabilities of modern large language models to understand architectural differences.

Suggested List of Experiments: Students are required to complete at least 10 experiments.

Sr. No.	Title of Experiments	LO
1	**Basic Text Preprocessing Techniques** **Task:** You are given raw, unstructured text data and need to clean and prepare it for analysis. Using Python in Jupyter Notebook with NLTK, spaCy, and regex, you will apply basic preprocessing techniques like tokenization, filtering, script validation, stopword removal, stemming, and lemmatization. The aim is to convert noisy text into meaningful and structured tokens for further processing. **Tools:** Python, Jupyter Notebook, NLTK, spaCy, regex.	LO1
2	**Morphological Analysis** **Task:** Perform morphological analysis on input text to extract root words and morphemes, and generate new word forms using inflectional and derivational rules. Input is raw text and output is root forms, morphemes, and generated word variants. Use stemming (e.g., Porter Stemmer in NLTK) for fast root extraction, or lemmatization (spaCy) for accurate dictionary forms. **Tools:** Python, Jupyter Notebook, NLTK, spaCy, morphological analyzers.	LO2
3	**Extraction of Email Addresses and Indian Mobile Numbers Using Regular Expressions** **Task:** Write a Python program using Regular Expressions to identify and extract all valid email addresses and Indian mobile numbers from an unstructured text document containing mixed information such as names, dates, and random numbers. **Tools:** Python, Jupyter Notebook or any Python IDE, re (Regular Expressions) module.	LO2
4	**Implementation of N-Gram Language Model** **Tasks:** You are developing a simple language model to understand how words appear in sequence within a text. Using a given dataset, you will generate unigrams, bigrams, and trigrams, and calculate their probabilities. This helps in predicting the next word and understanding basic language patterns. **Tools:** Python, Jupyter Notebook, NLTK, NumPy.	LO2
5	**Evaluation of N-Gram Models Using Laplace and Good-Turing Smoothing** **Tasks:** Apply Laplace and Good-Turing smoothing techniques to N-gram language models and evaluate their impact on text prediction accuracy using appropriate metrics. **Tools:** Python, Jupyter Notebook, NLTK, NumPy.	LO2
6	**Perform chunking (shallow parsing) on text to extract phrases like noun phrases (NP) and verb phrases (VP)** **Tasks:** Perform chunking on the given text input to identify and extract syntactic phrases such as noun phrases and verb phrases. Example: "The quick brown fox jumps" → [NP: *The quick brown fox*] [VP: *jumps*] **Tools:** Python, Jupyter Notebook, NLTK, spaCy.	LO3

7	**Study of Part-of-Speech Taggers and POS Tagging** **Tasks:** Study different types of POS taggers (rule-based, statistical) and perform Part-of-Speech tagging on given text. Implement a simple rule-based POS tagger by hardcoding at least 5 grammar rules (e.g., words ending with "-ing" → Verb, "-ly" → Adverb, "-ness" → Noun, capitalized words → Proper Noun, determiners like "the/a" → Determiner) and apply them along with NLTK/spaCy tagging. **Tools:** Python, Jupyter Notebook, NLTK, spaCy.	LO3
8	**Demonstration of Viterbi Algorithm for HMM-Based POS Tagging** **Tasks:** Demonstrate the Viterbi algorithm for HMM-based POS tagging by first computing transition and emission probability tables from a given dataset, and then using them to find the most probable tag sequence for a sentence. **Tools:** Python, Jupyter Notebook, NumPy, NLTK.	LO3
9	**Word Sense Disambiguation Using Lesk Algorithm** **Task:** Select a sentence containing an ambiguous target word (e.g., bank). Retrieve all possible senses of the word using WordNet and extract their definitions. Compare the context words of the sentence with each sense's gloss to compute overlap. Choose the sense with the maximum overlap as the correct meanin **Tools:** Python, NLTK.	LO4
10	**Word Embeddings Using Word2Vec and GloVe** **Tasks:** Generate word embeddings using CBOW and Skip-gram (Word2Vec) and GloVe, and visualize them using dimensionality reduction (e.g., PCA/t-SNE). Analyze semantic relationships by checking similarity between words (e.g., king – man + woman ≈ queen) and observe clustering of related words. **Tools:** Python, Gensim, NumPy	LO4
11	**TF-IDF and Document Similarity Analysis** **Tasks**: Convert text documents into numerical vectors using TF-IDF by calculating term frequency (TF), inverse document frequency (IDF), and TF-IDF scores. Compute similarity between documents using measures like cosine similarity to identify how closely related the documents are. **Tools:** Python, scikit-learn, NumPy	LO4
12	**Study of Transformer Architecture and Self-Attention Mechanism** **Task:** Study Large Language Models (LLMs) and explore the core components of the Transformer model, including self-attention, positional encoding, and encoder–decoder architecture using sample text data. **Tools:** Python, Jupyter Notebook, NumPy, PyTorch/TensorFlow, HuggingFace Transformers.	LO5
13	**Text Classification Using BERT Fine-Tuning** **Tasks:** Fine-tune a pretrained BERT model on a labeled text dataset to perform text classification and evaluate its performance using appropriate metrics. **Tools:** Python, Jupyter Notebook, HuggingFace Transformers, PyTorch/TensorFlow, scikit-learn, datasets library.	LO5

14	**Named Entity Recognition (NER) on Text Data** **Tasks:** Implement NER to identify and classify entities such as person names, locations, organizations, dates, and numerical values from input text. Apply pretrained models (NLTK/spaCy) on a sample dataset and analyze the extracted entities. **Tools:** Python, Jupyter Notebook, NLTK or spaCy, pretrained NER models, sample text dataset	LO6
15	**Exploration of Modern NLP Models (GPT-4, Llama-3, Claude-3, Mistral, Gemini)** **Task:** Compare outputs of modern LLMs on the same text prompt and analyze differences in responses without coding complex models. **Tools:** Web access to LLM APIs or interfaces, Python/Jupyter Notebook (optional for logging results).	LO6

Textbooks:

1. Joseph Babcock, Raghav Bali, "Generative AI with Python and TensorFlow", Packt Publishing, 2021.
2. Daniel Jurafsky, James H. and Martin, Speech and Language Processing, Third Edition, Prentice Hall, 2026.
3. Christopher D.Manning and HinrichSchutze, Foundations of Statistical Natural Language Processing, MIT Press, 1999.
4. Pushpak Bhattacharyya and Aditya Joshi, Natural Language Processing, Wiley India Pvt. Ltd., Edition: 2023.
5. Dr. Tanmoy Chakraborty, “Introduction to Large Language Models: Generative AI for Text” , Wiley (Wiley India). December 2024.

Reference books:

1. Daniel M Bikel and ImedZitouni — Multilingual natural language processing applications: from theory to practice, IBM Press, 2013.
2. Palash Goyal, Sumit Pandey, Karan Jain. *Deep Learning for Natural Language Processing*-2018

Online Resources:

- Virtual lab: https://nlp-iiith.vlabs.ac.in/List%20of%20experiments.html
- Stanford CS224N: https://web.stanford.edu/class/cs224n/
- NLTK https://www.nltk.org/
- spaCy https://spacy.io/
- Kaggle https://www.kaggle.com/

Term Work:

Term work shall consist of at least 12 experiments (Ensure that all the LOs are covered.)
The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work. Term work will be assessed as Continuous Internal Assessment Practical (CIAP).

Term work Marks:

- 25 Marks (Total Marks) =20 Marks (Experiment) + 05 Marks (Attendance)
- The final certification and acceptance of term work ensures satisfactory performance of laboratory work and minimum passing marks in term work.

Practical Exam: (2 hours/ 25 Marks)

- End-semester Practical and oral exam will be held based on the above syllabus and will be conducted as End Semester Examination Practical (ESEP).

Course Code	Course Name	Teaching Scheme (Hrs.)			Credits Assigned			
		Theory	Practical	Tutorial	Theory	Practical	Tutorial	Total
MDML6022	Decision Making and Business Intelligence Lab	--	02	--	--	01	--	01

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE			
		ISE	MSE				
MDML6022	Decision Making and Business Intelligence Lab	--	--	--	25	--	25

Course pre- requisite:

1. ETL303: Skill Lab - Python Programing

Program Outcomes Addressed

1. PO1: Engineering Knowledge:
2. PO2: Problem Analysis
3. PO3: Design/Development of Solutions
4. PO4: Conduct Investigations of Complex Problems
5. PO5: Engineering Tool Usage
6. PO9: Communication
7. PO11: Lifelong Learning

Lab Objectives:

1. To build a strong practical foundation in decision-making concepts.
2. To enable learners to use decision analysis tools.
3. To develop hands-on skills in data collection, profiling, cleaning, and transformation.
4. To introduce learners to the fundamentals of BI tools.
5. To guide learners in designing business-oriented KPIs and metrics.
6. To provide experience in developing end-to-end BI solutions.

Lab Outcomes:

Upon completion of this course, Learners will be able to:

1. Identify decision types and apply decision-support techniques.
2. Use analytical tools like what-if, goal seek, and sensitivity analysis.
3. Perform data preparation activities.
4. Develop BI reports and create interactive dashboards.
5. Design KPIs, metrics, and visualizations.
6. Construct interactive dashboards and small-scale BI solutions.

Suggested List of Experiments:

Sr. No.	Title of Experiments	LO
1	**Study of Decision Types and Decision Environments** a. Identify real-world examples of structured, semi-structured, and unstructured decisions. b. Analyse scenarios under certainty, risk, and uncertainty	LO1
2	**Implement What-If Analysis using Spreadsheet Tools** Vary input parameters and observe impact on output (e.g., sales forecasting, profit estimation).	LO1
3	**Goal Seek Technique for Decision Making** Use spreadsheet tools to determine required input to achieve a desired goal (e.g., break-even point).	LO2
4	**Design a Simple Decision Support System (DSS) Model** Build a small DSS model using formulas, functions, and macros for a given business scenario.	LO2
5	**Scenario Analysis and Multi-Criteria Decision Making (MCDM) using Spreadsheets** a. Define a decision problem with 3–5 alternatives and multiple criteria (e.g. cost, time, quality, risk). b. Assign weights to criteria. c. Use spreadsheet to compute a score for each alternative (weighted sum or simple normalized scoring).	LO2
6	**Data Collection and Data Profiling** a. Collect a dataset (CSV/Excel). b. Perform profiling: check data types, missing values, ranges, outliers	LO3
7	**Data Cleaning and Transformation** a. Perform data cleaning (handling missing values, duplicates, formatting). b. Apply transformations (normalizing, merging, splitting columns	LO3
8	**Design a dashboard that helps a business manager monitor sales performance.** a. Explain which KPIs you would include, how you would structure the layout, and what interactive elements (filters, drill-downs, slicers) you would add to support decision-making.	LO4
9	**Creating KPIs and Metrics for BI Reporting** a. Identify KPIs for a problem statement (e.g., sales, HR, finance). b. Design metric calculations in spreadsheet or BI tool.	LO4
10	**Designing BI Reports using visualization tools** a. Import cleaned data. b. Create basic reports (tables, cards, simple charts)	LO5
11	**Data Integration from Multiple Sources** a. Combine datasets from different sources (CSV + Excel, or two Excel sheets). b. Resolve schema mismatches and perform basic joins using spreadsheet or Power Query	LO5
12	**Interactive Dashboard Creation** a. Create dashboards with slicers/filters. b. Add interactive visuals like bar charts, line charts, KPI cards.	LO6
13	**Introduction to Visualization – Data Import and Basic Charts** a. Import data in Tool. b. Create bar, line, pie charts, tables. c. Work with dimensions and measures.	LO6

14	**Cloud-Based BI using Cloud BI** a. Upload cleaned dataset to cloud storage or connect via web source b. Build BI reports/dashboards on cloud BI platform (simulate remote team access)	LO6
15	**BI Case Study** a. Students prepare a BI solution for any domain: i. Retail ii. HR iii. Healthcare iv. Banking v. Manufacturing b. Includes data preparation, visualization, dashboards, insights, and recommendations.	LO6

Textbooks:

1. E. Turban, R. Sharda, and D. Delen, Decision Support and Business Intelligence Systems, 10th ed. Pearson, 2014.
2. J. R. Evans, Business Analytics: Methods, Models, and Decisions, 2nd ed. Pearson, 2016.
3. N. Godbole, Business Intelligence, 1st ed. Wiley India, 2013.
4. L. T. Moss and S. Atre, Business Intelligence Roadmap: The Complete Project Lifecycle for Decision-Support Applications, 1st ed. Addison-Wesley, 2003.

Reference books:

1. T. H. Davenport and J. Harris, Competing on Analytics: The New Science of Winning, 1st ed. Harvard Business Review Press, 2007.
D. Vercellis, Business Intelligence: Data Mining and Optimization for Decision Making, 1st ed. Wiley, 2009. (BI sections only)
2. W. L. Winston, Microsoft Excel Data Analysis and Business Modeling, 4th ed. Microsoft Press, 2014.
3. P. Ponniah, Data Preparation for Analytics Using SAS, 1st ed. Wiley, 2017.

Online Resources:

1. Microsoft Power BI Learning Path
   https://learn.microsoft.com/power-bi/
2. Tableau Learning Resources
   https://www.tableau.com/learn
3. Google Data Studio (Looker Studio) Tutorials
   https://support.google.com/looker-studio

Term Work:

- Term work shall consist of at least 12 experiments (Ensure that all the LOs are covered).
- The final certification and acceptance of term work ensure satisfactory performance of laboratory work and minimum passing marks in term work. Term work will be assessed as Continuous Internal Assessment Practical (CIAP).

Term work Marks (CIAP):

- 25 Marks (Total Marks) =20 Marks (Experiment) + 05 Marks (Attendance)
- The final certification and acceptance of term work ensure satisfactory performance of laboratory work and minimum passing marks in term work.

Course Code	Course Name	Credits Assigned			
		Theory	Practical	Tutorial	Total
ETP601	Major Project I	--	2	--	2

Course Code	Course Name	Examination Scheme					
		Theory Marks			CIAP	ESEP	Total
		Course Assessment		ESE			
		ISE	MSE				
ETP601	Major Project I	--	--	--	25	25	50

Program Outcomes addressed:

1. PO1: Engineering knowledge.
2. PO2: Problem Analysis.
3. PO3: Design/Development of Solutions.
4. PO4: Conduct Investigations of Complex Problems.
5. PO5: Engineering Tool Usage.
6. PO6: The Engineer and The World.
7. PO7: Ethics.
8. PO8: Individual and Collaborative Team work.
9. PO9: Communication.
10. PO10: Project Management and Finance.
11. PO11: Life-Long Learning.

Objectives:

1. Investigate and evaluate prominent literature to come with application-oriented project topics in connection with the curriculum.
2. Study and develop an outline for thinking and practice that illuminates and brings insight to the design and implementation aspects with respect to the project topic.
3. Design and create practical resources and solution aspect for the design and implementation.
4. Present an organised exploratory framework, while understanding the documentary deliverables within established academic practices and/ or ideas.
5. Offer inquiry-based argumentation / presentation along with project implementation
6. To promote self-learning and research-oriented thinking.

Outcomes: Upon completion of this course, learners will be able to:

1. Perform extensive Review of Literature from diverse knowledge banks or through interactions with Industry experts.
2. Developing or Creating ideas capable of addressing industrial or social solutions to identified problem domains.
3. Acquire knowledge of tools & technologies and application of their expertise in creating project implementation and deliverables.
4. Implement solutions using appropriate technologies, engineering practices, and version control.
5. Test and validate the system through structured test cases, datasets, and simulations.
6. Compose technical documentation, present project outcomes, and demonstrate teamwork, ethics, and self-learning.

1. **Guidelines for Project topic selection Process to be defined and followed:**

1.1 General Guidelines

a. Project orientation can be given at the end of fifth semester.
b. Students should be informed about the domain and domain experts whose guidance can be taken before selecting projects.
c. Students can select the problem statement from the Industry and provide technology solution as capstone project. Capstone projects in engineering study are considered important as it allow students to integrate and apply the knowledge and skills acquired throughout their academic program and effectively demonstrating their learning of programme by tackling a real-world problem, ultimately keeping them well prepared for the job market
d. Student‘s should be recommended to refer papers from reputed conferences/ journals like IEEE, Elsevier, ACM etc. which are not more than 3 years old for review of literature.
e. Students can certainly take ideas from anywhere, but be sure that they should evolve them in the unique way to suit their project requirements. Students can be informed to refer Digital India portal, SIH portal or any other hackathon portal for problem selection.

1.2 Topics can be finalized with respect to following criterion:

a. Topic Selection: The topics selected should be novel in nature (Product based, Application based or Research based) or should work towards removing the lacuna in currently existing systems.
b. Technology Used: Use of latest technology or modern tools can be encouraged.
c. Students should not repeat work done previously (work done in the last three years).
d. Project work must be carried out by the group of at least 2 students and maximum 4.
e. The project work can be undertaken in a research institute or organization/Industry/any business establishment. (out-house projects)
f. The Capstone Project- problems must be related to the programme or may be interdisciplinary, based on the industry expected outcomes.The individual students have different aptitudes and strengths. Project work, therefore, should match the strengths of students. For this purpose, students should be asked to identify the type of project work they would like to execute.
g. Project shall address National Thrust area such as Environment, Digitization, Automation, sustainability and predefined Sustainable development goals(SDGs).
h. The project proposal presentations can be scheduled according to the domains and should be judged by faculty who are expert in the domain.
i. Head of department and senior staff along with project coordinators will take decision regarding final selection of projects.
j. Guide allocation should be done and students have to submit weekly progress report to the internal guide.
k. Internal guide has to keep track of the progress of the project and also has to maintain attendance report. This progress report can be used for awarding term work marks.
l. In case of industry/ out-house projects, visit by internal guide will be preferred and external members can be called during the presentation at various levels.

1.3 Deployment Requirement

a. Each project must include a deployment phase, ensuring the solution is usable in a real-world or simulated environment.

Examples of deployment include:

- Web application hosted on cloud/server
- Mobile application (APK/Test version/Play Store)
- Industrial automation system implemented or simulated
- AI/ML model deployed via API or dashboard
- IoT system with real-time monitoring and control

2. Guidelines for Assessment of Major Project I:

1.1 Term Work Evaluation (CIAP)

a. A Review/Progress Monitoring Committee shall be constituted by the Head of Department. **Major Project I** shall be evaluated continuously, with a minimum of two reviews per semester.
b. Continuous assessment should also emphasize individual performance, including each student's contribution, understanding of the project, and responses during review interactions.
c. Project report to be submitted as per the guidelines issued by the department.
d. Term work will be assessed as Continuous Internal Assessment Practical (CIAP).

2.2 Distribution of marks

The distribution of Term Work marks for the semester shall be as follows:

a. Marks by Guide/Supervisor based on Logbook: 10
b. Marks by Review Committee: 10
c. Quality of Project Report: 05

1.3 Evaluation Rubrics CIAP (Term work);

a. Quality of literature survey and need identification
b. Clarity of problem definition
c. Innovation and creativity
d. Feasibility and justification of approach
e. Cost effectiveness and societal/environmental impact (SDGs)
f. Quality of system design and use of engineering norms
g. Implementation quality and functioning of prototype
h. Effective use of technical skill sets and tools
i. Teamwork, leadership, and individual contribution
j. Clarity in documentation, presentation, and communication
k. Deployment readiness and implementation feasibility
l. Usability, scalability, and real-world applicability of the deployed solution

1.4 ESEP (Practical/Oral) Examination:

a. **Major Project I** shall be assessed through a presentation and demonstration of working model by the student project group to a panel of Internal and External Examiners preferably from industry or research organizations having experience of more than five years approved by the head of Institution.
b. Students shall be motivated to publish a paper based on the work in Conferences/students competitions.
c. End-semester Practical / oral exam will be held based on the above syllabus and will be conducted as End Semester Examination Practical (ESEP).

1.5 Evaluation Rubrics ESEP (Practical / Oral):

a. Problem identification and clarity
b. Innovation in solution
c. Feasibility and societal impact
d. Working model functionality
e. Effective use of engineering tools
f. Adherence to standards and norms
g. Teamwork and individual contribution
h. Communication skills
i. Deployment quality (hosting, execution, usability, and performance)

Internal Assessment:

For 03 credit - 80 marks subject

Assessment consists of one Mid Semester Examination (MSE) of 20 marks and In Semester Examination (ISE) of 20 marks. The MSE is to be conducted based on a 50% syllabus with a duration of one hour.

For 02 credit - 60 marks subject

Assessment consists of one Mid Semester Examination (MSE) of 15 marks and In Semester Examination (ISE) of 15 marks. The MSE is to be conducted based on a 50% syllabus with a duration of one hour.

In Semester Examination (ISE)

ISE 20 marks = 05 marks of attendance +15 marks for Activities.

ISE 15 marks = 05 marks of attendance +10 marks for Activities.

The Rubrics for activities are as follows. The activities will be decided by the course in charge and approved by HoD.

Sr.No	Rubrics	Marks
1	Multiple Choice Questions (Quiz)	05 Marks
2	Literature review of papers/journals	05 Marks
3	Participation in event/ workshop/ talk / competition followed by small report and certificate of participation relevant to the subject	05 Marks
4	Extra Experiments/Virtual Lab	05 Marks
5	Content beyond syllabus presentation	05 Marks
6	Winning the event/competition/hackathon pertaining to the course	10 Marks
7	Case study, Presentation, group discussion, technical debate on recent trends in the said course	10 Marks
8	NPTEL/Coursera/Udemy/any MOOC Certificate course for 4weeks or more	10 Marks
9	Creating Proof of Concept	10 Marks
10	Mini Project	10 Marks
11	GATE Based Assignment test/Tutorials etc.	10 Marks

*For sr.no.8, the date of certification exam should be within the term and in case a student is unable to complete the certification, the grading must be done accordingly.