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Updated in October 2025 upon incorporating various decisions of the Senate

B.Tech. in Computer Science and Engineering (167 credits)

SEMESTER -1

Sl no	Course Code	Subjects	Credits	L-T-P
1	EE101	Fundamentals of Electrical and Electronics	4	3-0-2
2	ES101	Engineering Physics	4	3-0-2
3	ES102	Engineering Mathematics	4	3-1-0
4	EE102	Engineering Design Principles	3	2-0-2
5	CS101	Principles of Computer Programming	4	3-0-2
6	HS101	Freshman Skills	2	2-0-0
7	HS102	Sports and Physical Education	2	0-1-2
		Total	**23 Credits**	

SEMESTER -2

Sl no	Course Code	Subjects	Credits	L-T-P
1	EE103	Digital Electronics	4	3-0-2
2	ES103	Probability and Statistics	4	3-1-0
3	CS102	Data Structures	4	3-0-2
4	EE104	Hardware Workshop	3	2-0-2
5	CS103	Object Oriented Programming	4	3-0-2
6	HS103	Ecology and Environment Sciences	2	2-0-0
7	CS104	Mobile Application Technologies	2	0-1-2
		Total	**23 credits**	
	MO-1 (Optional)		2/3-0-0	

EXIT AFTER YEAR – 1 → **Certificate in Engineering Sciences (46 credits)**

SEMESTER -3

Sl no	Course Code	Subjects	Credits	L-T-P
1	HS201	Indian Culture, Ethics and Moral Values	2	2-0-0
2	CS201	Discrete Structures	4	3-1-0
3	CS202	Computer Organization and Architecture	4	3-0-2
4	CS203	Design and Analysis of Algorithms	4	3-0-2
5	CS204	Database Systems	4	3-0-2
6	CS205	Paradigms of Programming Languages	4	3-0-2
		Total	**22 credits**	

SEMESTER -4

Sl no	Course Code	Subjects	Credits	L-T-P
1	HS202	Entrepreneurship and Innovation	2	2-0-0
2	CS206	Theory of Computation	3	3-0-0
3	CS207	Operating Systems	4	3-0-2
4	CS208	Computer Networks	4	3-0-2
5	CS209	Mathematical Foundations of Computing	4	3-1-0
6	CS210	Software Engineering	4	3-0-2
		Total	**21 credits**	
	MO-2 (Optional)		2/3-0-0	

EXIT AFTER YEAR - 2 → **Diploma in Computer Science and Engineering (89 credits)**

SEMESTER -5

Sl no	Course Code	Subjects	Credits	L-T-P
1	MS301	Business Economics	3	3-0-0
2	CS0XX	Department Elective-1	3	3-0-0
3	CS304	Data Analytics and Visualisation	3	3-0-0
4	CS301	Compiler Design	4	3-0-2
5	CS302	Computer Graphics	4	3-0-2
6	CS303	Trustworthy Artificial Intelligence	4	3-0-2
		Total	**21 credits**	

SEMESTER -6

Sl no	Course Code	Subjects	Credits	L-T-P
1	EN301	Art of Engineering Research	2	2-0-0
2		Multidisciplinary/Open Elective- 1/MOOC 1	3	3-0-0
3	CS0XX	Department Elective-2	3	3-0-0
4	CS305	Nature Inspired Computing	3	3-0-0
5	CS306	Machine Learning	4	3-0-2
6	CS307	Information Security Systems	4	3-0-2
		Total	**19 credits**	

Colloquium of 3 credits in summer semester (MOOC, NPTEL etc. in lieu of colloquium)

EXIT AFTER YEAR - 3 → **BSc in Computer Science and Engineering (129 credits)**

SEMESTER -7

Sl no	Course Code	Subjects	Credits	L-T-P
1		Multidisciplinary/Open Elective- 2/MOOC 2	3	3-0-0
2	CS0XX	Department Elective -3	3	3-0-0
3	CS401	Natural Language Processing	4	3-0-2
4	CS402	Digital Image Processing	4	3-0-2
5	CS403	Cloud Computing	3	3-0-0
6	CS404	Big Data Analytics	3	3-0-0
7	CS498	Colloquium (Based on industrial training)/MOOC	3	0-0-6
		Total	**23 credits**	

SEMESTER -8

Sl no	Course Code	Subjects	Credits	L-T-P
1	CS499	BTech Project/Internship	12	0-0-24
2		Multidisciplinary/Open Elective- 3/MOOC 3	3	3-0-0
		Total	**15 credits**	

FINAL EXIT AFTER YEAR – 4 → **BTech. In Computer Science and Engineering (167 credits)**

Courses for the Minor in CSE (Total 23 credits required)

Sl no.	Subject	Code	L-T-P	Credits
1	Design and Analysis of Algorithms	CS203	3-0-2	4
2	Database Systems	CS204	3-0-2	4
3	Operating Systems	CS207	3-0-2	4
4	Computer Networks	CS208	3-0-2	4
5	Software Engineering	CS210	3-0-2	4
6	CSE Elective Course	CS0XX	3-0-0	3

B.Tech (CSE) Department Elective Courses

Sl no.	Subject	Code	L-T-P	Credits
1	Graph Theory	CS001	3-0-0	3
2	Software, System Analysis and Design	CS002	3-0-2	4
3	Digital Signal Processing	CS003	3-0-0	3
4	Microprocessor and Interfacing	CS004	3-0-2	4
5	Cryptography and Network Security	CS005	3-0-0	3
6	Control System Engineering	CS006	3-0-0	3
7	System Simulation and Modeling	CS007	3-0-0	3
8	IoT Protocols	CS008	3-0-0	3
9	Game Programming	CS009	3-0-0	3
10	Formal languages and Automata	CS010	3-0-0	3
11	Advanced Network Technologies	CS011	3-0-0	3
12	Empirical Techniques in Software Engineering	CS012	3-0-0	3
13	Digital Water Marking and Steganalysis	CS013	3-0-0	3
14	Deep Learning	CS014	3-0-0	3
15	Blockchain Technology	CS015	3-0-0	3
16	Introduction to Robotics	CS016	3-0-0	3
17	Stochastic Processes and Queuing Theory	CS017	3-0-0	3
18	Advanced Competitive Programming	CS018	3-0-0	3
19	Network Programming	CS019	3-0-0	3
20	Combinatorial Mathematics	CS020	3-0-0	3
21	Network Design and Optimization	CS021	3-0-0	3
22	Software reliability	CS022	3-0-0	3
23	Computer Vision	CS023	3-0-0	3
24	Recommender Systems	CS024	3-0-0	3
25	Modern Cryptography	CS025	3-0-0	3
26	Robot Motion Planning	CS026	3-0-0	3
27	Optimization Techniques	CS027	3-1-0	4
28	Game Theory and Applications	CS028	3-0-0	3
29	Human – Computer Interaction	CS029	3-0-0	3
30	Randomized Algorithms	CS030	3-0-0	3

B.Tech. in Electrical and Electronics Engineering (169 credits)

SEMESTER -1

Sl no	Course Code	Subjects	Credits	L-T-P
1	EE101	Fundamentals of Electrical and Electronics	4	3-0-2
2	ES101	Engineering Physics	4	3-0-2
3	ES102	Engineering Mathematics	4	3-1-0
4	EE102	Engineering Design Principles	3	2-0-2
5	CS101	Principles of Computer Programming	4	3-0-2
6	HS101	Freshman Skills	2	2-0-0
7	HS102	Sports and Physical Education	2	0-1-2
		Total	**23 credits**	

SEMESTER -2

Sl no	Course Code	Subjects	Credits	L-T-P
1	EE103	Digital Electronics	4	3-0-2
2	ES103	Probability and Statistics	4	3-1-0
3	IT102	Data Structures	4	3-0-2
4	EE104	Hardware Workshop	3	2-0-2
5	CS103	Object Oriented Programming	4	3-0-2
6	HS103	Ecology and Environment Sciences	2	2-0-0
7	CS104	Mobile Application Technologies	2	0-1-2
		Total	**23 credits**	
	MO101	MOOC1 (Optional in Summer)	2/3	

EXIT AFTER YEAR – 1. **Certificate in Engineering Sciences (46 credits)**

SEMESTER -3

Sl no	Course Code	Subjects	Credits	L-T-P
1	HS201	Indian Culture, Ethics and Moral Values	2	2-0-0
2	EE207	Signals & Systems	4	3-1-0
3	EE202	Network Analysis & Synthesis	4	3-1-0
4	CS202	Computer Organization & Architecture	4	3-0-2
5	EE203	Microelectronics: Devices and Materials	4	3-0-2
6	EE208	Electromagnetic theory	4	3-1-0
		Total	**22 credits**	

SEMESTER -4

Sl no	Course Code	Subjects	Credits	L-T-P
1	MS619	Entrepreneurship and Innovation	2	2-0-0
2	EE302	System Design using HDL	4	3-0-2
3	EE303	Microprocessor and Interfacing	4	3-0-2
4	EE201	Principles of Communication	4	3-0-2
5	EE204	Analog Electronics	4	3-0-2
6	EE209	Control System	4	3-1-0
		Total	**22 credits**	
	MO101	MOOC2 (Optional in Summer)	2	

EXIT AFTER YEAR - 2 **Diploma in Electrical and Electronics Engineering (90 credits)**

SEMESTER -5

Sl no	Course Code	Subjects	Credits	L-T-P
1	MS603	Business Economics	3	3-0-0
2		Multidisciplinary / Open Elective- 1/MOOC3	3	3-0-0
3		Department Elective-1	3	3-0-0
4	EE301	Digital Signal Processing	4	3-0-2
5	EE205	VLSI Design	4	3-0-2
6	EE206	Wireless Communication	4	3-1-0
		Total	**21 credits**	

SEMESTER - 6

Sl no	Course Code	Subjects	Credits	L-T-P
1	EN301	Art of Engineering Research	2	2-0-0
2		Multidisciplinary / Open Elective- 2/ MOOC4	3	3-0-0
3		Department Elective-2	3	3-0-0
4	EE304	IoT and Applications	4	3-0-2
5	EE305	RF Circuit & Antenna Design	4	3-0-2
6	EE306	Microcontroller and Embedded Systems	4	3-0-2
		Total	**20 credits**	

Colloquium of 3 credits in summer semester (MOOC, NPTEL etc. in lieu of colloquium)

EXIT AFTER YEAR - 3 → **BSc in Electrical and Electronics Engineering (131 credits)**

SEMESTER - 7

Sl no	Course Code	Subjects	Credits	L-T-P
1		Multidisciplinary / Open Elective- 3/MOOC5	3	3-0-0
2		Department Elective -3	3	3-0-0
3	EE401	Trustworthy AI and Machine learning	4	3-0-2
4	EE402	Intelligent Transportation Systems	3	3-0-0
5	EE403	Power Electronics	4	3-0-2
6	EE404	IC Technology	3	3-0-0
7	EE498	Colloquium (Based on industrial training)/MOOC	3	0-0-6
		Total	**23 credits**	

SEMESTER - 8

Sl no	Course Code	Subjects	Credits	L-T-P
1	EE499	BTech Project/Internship	12	0-0-24
2		Multidisciplinary / Open elective – 4 / MOOC6	3	3-0-0
		Total	**15 credits**	

FINAL EXIT AFTER YEAR – 4 → **B.Tech. in Electrical and Electronics Engineering (169 credits)**

Courses for the Minor in EEE (Total 24 credits required)

Sl	Code	Course Name	Credits	L-T-P
1	EE207	Signals & Systems	4	3-1-0
2	EE204	Analog Electronics	4	3-0-2
3	EE205	VLSI Design	4	3-0-2
4	EE303	Microprocessor and Interfacing	4	3-0-2
5	EE304	IoT and Applications	4	3-0-2
6	EE201	Principles of Communication	4	3-0-2
		Total credits	**24**	

Multidisciplinary Electives offered by EEE Department				
Sl	**Code**	**Course Name**	**Credits**	**L-T-P**
1	EE204	Analog Electronics	4	3-0-2
2	EE207	Signals & Systems	4	3-1-0
3	EE303	Microprocessor and Interfacing	4	3-0-2
4	EE205	VLSI Design	4	3-0-2
5	EE201	Principles of Communication	4	3-0-2
6	EE304	IoT and Applications	4	3-0-2
7	EE002	Quantum Electronics	3	3-0-0
8	EE006	Design Verification and Testing	3	3-0-0
9	EE007	Device and Interconnect Modelling	3	3-0-0
10	EE015	Information Theory and Coding	3	3-0-0
11	EE028	Drone Technology and Robotics	3	3-0-0

List of Electives

VLSI and Embedded System					
Sl	**Code**	**Course Name**	**Prerequisite**	**Credits**	**L-T-P**
1	EE001	VLSI Architecture	EE205, EE302	3	3-0-0
2	EE002	Quantum Electronics	EE203, EE204	3	3-0-0
3	EE003	Introduction to MEMS	EE304	3	3-0-0
4	EE004	VLSI Signal Processing	EE205, EE201	3	3-0-0
5	EE005	FPGA-based System Design	EE205	3	3-0-0
6	EE006	Design Verification and Testing	EE205	3	3-0-0
7	EE007	Device and Interconnect Modelling	EE205	3	3-0-0
8	EE008	CAD for VLSI	EE205	3	3-0-0
9	EE009	Memory Devices and Circuits	EE205	3	3-0-0
10	EE010	Embedded Software	EE306	3	3-0-0
11	EE011	Organic Semiconductors	EE203	3	3-0-0
12	EE012	Solar Cells-Fundamental & Applications	EE203	3	3-0-0
13	EE013	Energy Storage Materials	EE203	3	3-0-0

Communication and Signal Processing					
Sl	**Code**	**Course Name**	**Prerequisite**	**Credits**	**L-T-P**
1	EE014	Communication Networks and Switching	EE303	3	3-0-0
2	EE015	Information Theory and Coding	ES102, ES103	3	3-0-0
3	EE016	High-Performance Computing	EE401	3	3-0-0
4	EE017	Biomedical Signal Processing	EE301	3	3-0-0
5	EE018	Neuromorphic Computing	EE401	3	3-0-0
6	EE019	Advance Signal Processing	EE301	3	3-0-0
7	EE020	Optical Communication	EE207	3	3-0-0
8	EE021	Advanced Communication Engineering	EE207	3	3-0-0
9	EE022	Speech and Audio Signal Processing	EE301	3	3-0-0
10	EE036	Digital Communication	EE201	3	3-0-0
11	EE037	Microwave Circuits Design	EE202, EE208	3	3-0-0
12	EE038	RFIC Design	EE203	3	3-0-0

Autonomous and Intelligent Systems					
Sl	**Code**	**Course Name**	**Prerequisite**	**Credits**	**L-T-P**
1	EE023	Sensors for Autonomous Systems	EE304	3	3-0-0
2	EE024	Power Systems	EE403	3	3-0-0
3	EE025	Power Electronic Converters for Renewable Energy	EE403	3	3-0-0
4	EE026	Smart Grid Technology	EE403	3	3-0-0
5	EE027	Electromechanics	EE403	3	3-0-0
6	EE028	Drone Technology and Robotics	EE304	3	3-0-0
7	EE029	Intelligent Control System	EE209	3	3-0-0
8	EE030	Image Computing	EE207	3	3-0-0
9	EE031	Time-Frequency Analysis	EE207	3	3-0-0
10	EE032	Machine Intelligence	NA	3	3-0-0
11	EE033	Speech and Audio Processing	EE207, EE209	3	3-0-0
12	EE034	Intelligent Vision Systems	EE207, EE209	3	3-0-0
13	EE035	Biomedical Engineering	NA	3	3-0-0

B.Tech. in Mathematics and Scientific Computing (175-186 credits)

SEMESTER - 1

Sl no.	Course Code	Subject	Credits	L-T-P
1.	EE101	Fundamentals of Electrical and Electronics	4	3-0-2
2.	ES101	Engineering Physics	4	3-0-2
3.	ES102	Engineering Mathematics	4	3-1-0
4.	EE102	Engineering Design Principles	3	2-0-2
5.	CS101	Principles of Computer Programming	4	3-0-2
6.	HS101	Freshman Skills	2	2-0-0
7.	HS102	Sports and Physical Education	2	0-1-2
		Total	**23 credits**	

SEMESTER - 2

Sl no.	Course code	Subject	Credits	L-T-P
1.	EE103	Digital Electronics	4	3-0-2
2.	ES103	Probability and Statistics	4	3-1-0
3.	CS102	Data Structures	4	3-0-2
4.	EE104	Hardware Workshop	3	2-0-2
5.	IT103	Object Oriented Programming	4	3-0-2
6.	HS103	Ecology and Environment Sciences	2	2-0-0
7.	CS104	Mobile Application Technologies	2	0-1-2
		Total	**23 credits**	

***Summer Project or MOOC (Optional) of 2 credits**

EXIT AFTER YEAR – 1 → **Certificate in Engineering Sciences (46 credits)**

SEMESTER - 3

Sl no.	Course code	Subject	Credits	L-T-P
1.	HS201	Indian Culture, Ethics and Moral Values	2	2-0-0
2.	ES201	Discrete Structures	4	3-1-0
3.	ES202	Differential Equations and Integral Transformations	3	3-0-0
4.	ES203	Real and Functional Analysis	3	3-0-0
5.	CS203	Design and Analysis of Algorithms	4	3-0-2
6.	CS204	Database Systems	4	3-0-2
7.	ES204	Complex Analysis	3	3-0-0
		Total	**23 credits**	

SEMESTER - 4

Sl no.	Course code	Subject	Credits	L-T-P
1.	MS619	Entrepreneurship and Innovation	2	2-0-0
2.	CS207	Operating Systems	4	3-0-2
3.	CS210	Software Engineering	4	3-0-2
4.	ES207	Computer Networks	4	3-0-2
5.	ES206	Multivariate Data Analysis	4	3-0-2
6.	ES205	Advanced Numerical Methods	4	3-0-2
		Total	**22 credits**	
		MOOC Course (Optional)*	**2/3**	

***Summer Project-1**

EXIT AFTER YEAR – 2 → **Diploma in Mathematics & Scientific Computing (91-94 credits)**

SEMESTER - 5

Sl no.	Course code	Subject	Credits	L-T-P
1.	ES301	Fuzzy Sets and Applications	3	3-0-0
2.	ES302	Trustworthy Artificial Intelligence	4	3-0-2
3.	ES303	Vector Calculus	3	3-0-0
4.	CS302	Computer Graphics	3	3-0-0
5.	ES304	Software Reliability	3	3-0-0
6.	ES0XX	Department Elective-1	3/4	
7.	MS603	Business Economics	3	3-0-0
		Total	**22-23 credits**	

SEMESTER - 6

Sl no.	Course code	Subject	Credits	L-T-P
1.	ES305	Quantum Computing	3	3-0-0
2.	ES306	Optimization Techniques	4	3-1-0
3.	ES307	Statistical Inference	4	3-1-0
4.	ES308	AI and Machine Learning	3	3-0-0
5.		Multidisciplinary/Open Elective-1/MOOC	3/4	
6.		Department Elective -3	3/4	
7.	EN301	Art of Engineering Research	3	3-0-0
		Total	**23-25 credits**	
		MOOC, NPTEL Course (Optional)	**2**	

Colloquium of 2 credits in summer semester (MOOC, NPTEL etc. in lieu of colloquium)

EXIT AFTER YEAR – 3 → **B.Sc. in Mathematics & Scientific Computing (136-144 credits)**

SEMESTER - 7

Sl no.	Course code	Subject	Credits	L-T-P
1.	ES401	Modelling and Simulation	4	3-0-2
2.	ES402	Data Mining and Data warehousing	4	3-0-2
3.	ES403	Advanced Graph Theory	3	3-0-0
4.	ES404	Modern Cryptography	4	3-0-2
5.		Multidisciplinary/Open Elective-2/MOOC	3/4	
6.	ES0XX	Department Elective-4	3/4	
7.	ES498	Colloquium (Based on industrial training)/MOOC	3	0-0-6
		Total	**24-26 credits**	

SEMESTER - 8

Sl no.	Course code	Subject	Credits	L-T-P
1.	ES499	BTech Project/Internship	12	0-0-24
2.		Multidisciplinary/Open Elective- 3/MOOC	3/4	
		Total	**15-16 credits**	

FINAL EXIT AFTER YEAR – 4 → **B.Tech. in Mathematics & Scientific Computing (175-186 credits)**

Minor in Mathematics and Scientific Computing (Total 22 credits required)

Sl no.	Course code	Subject	Credit	L-T-P
1.	ES205	Advanced Numerical Methods	4	3-0-2
2.	ES203	Real and Functional Analysis	3	3-0-0
3.	ES204	Multivariate Data Analysis	4	3-0-2
4.	ES301	Fuzzy Sets and Applications	3	3-0-0
5.	ES401	Modelling and Simulation	4	3-0-2
6.	ES307	Statistical Inference	4	3-1-0
		Total credits	22	

Electives in Mathematics & Scientific Computing

Sl.	Code	Name of the course	Credit	L-T-P
1.	ES001	Parallel Computing	4	3-0-2
2.	ES002	Computational Biology	3	3-0-0
3.	ES003	Stochastic Processes and Applications	4	3-1-0
4.	ES004	Topology and Differential Geometry	4	3-1-0
5.	ES005	Data Economics	3	3-0-0
6.	ES006	Intuitionistic Fuzzy Sets and Applications	4	3-1-0
7.	ES007	Financial Mathematics	3	3-0-0
8.	ES008	Digital Image Processing	4	3-0-2
9.	ES009	Big Data Analytics	4	3-0-2
10.	ES010	Wavelet Analysis	3	3-0-0
11.	ES011	Introduction to Game Theory	3	3-0-0
12.	ES012	Computer Vision	4	3-0-2
13.	ES013	Business Statistics and Industrial Applications	4	3-1-0
14.	ES014	Robotics	4	3-0-2
15.	ES015	Dynamical System	3	3-0-0
16.	ES016	Computational Linear Algebra	4	3-1-0
17.	ES017	Computational Fluid dynamics	3	3-0-0
18.	ES018	Approximation and Estimation theory	3	3-0-0
19.	ES019	Microprocessor and Interfacing	4	3-0-2
20.	ES020	Software Defined Systems	3	3-0-0
21.	ES021	Cyber-Physical Systems	3	3-0-0
22.	ES022	Cloud Computing Technologies	3	3-0-0
23.	ES023	Immersive Technologies: AR & VR Applications	4	3-0-2

Integrated Postgraduate in Information Technology (B.Tech. + M.Tech.) (211 credits)

SEMESTER -1

Sl no	Course Code	Subjects	Credits	L-T-P
1	EE101	Fundamentals of Electrical and Electronics	4	3-0-2
2	ES101	Engineering Physics	4	3-0-2
3	ES102	Engineering Mathematics	4	3-1-0
4	EE102	Engineering Design Principles	3	2-0-2
5	IT101	Principles of Computer Programming	4	3-0-2
6	HS101	Freshman Skills	2	2-0-0
7	HS102	Sports and Physical Education	2	0-1-2
		Total	**23 Credits**	

SEMESTER -2

Sl no	Course Code	Subjects	Credits	L-T-P
1	EE103	Digital Electronics	4	3-0-2
2	ES103	Probability and Statistics	4	3-1-0
3	IT102	Data Structures	4	3-0-2
4	EE104	Hardware Workshop	3	2-0-2
5	IT103	Object Oriented Programming	4	3-0-2
6	HS103	Ecology and Environment Sciences	2	2-0-0
7	CS104	Mobile Application Technologies	2	0-1-2
		Total	**23 credits**	
	MO101	MOOC-1 (Optional in summer)	2/3	

EXIT AFTER YEAR – 1. **Certificate in Engineering Sciences (46 credits)**

SEMESTER -3

Sl no	Course Code	Subjects	Credits	L-T-P
1	HS201	Indian Culture, Ethics and Moral Values	2	2-0-0
2	IT201	Discrete Structures	4	3-1-0
3	IT202	Computer Organization and Architecture	4	3-0-2
4	IT203	Design and Analysis of Algorithms	4	3-0-2
5	IT204	Data Communications	4	3-0-2
6	IT205	Database Systems	4	3-0-2
		Total	**22 credits**	

SEMESTER -4

Sl no	Course Code	Subjects	Credits	L-T-P
1	MS619	Entrepreneurship and Innovation	2	2-0-0
2	IT206	Theory of Computation	3	3-0-0
3	IT207	Operating Systems	4	3-0-2
4	IT208	Computer Networks	4	3-0-2
5	EE201	Signals and Systems	4	3-1-0
6	IT209	Graph Theory	4	3-0-2
		Total	**21 credits**	
	MO201	MOOC-2 (Optional in summer)	2/3-0-0	

EXIT AFTER YEAR - 2 → **Diploma in Information Technology (89 credits)**

SEMESTER -5

Sl no	Course Code	Subjects	Credits	L-T-P
1	MS603	Business Economics	3	3-0-0
2		Multidisciplinary/Open Elective- 1	3	3-0-0
3	IT308	Nature Inspired computing	3	3-0-0
4	IT302	Compiler Design	4	3-0-2
5	IT303	Computer Graphics	4	3-0-2
6	IT304	Trustworthy Artificial Intelligence	4	3-0-2
		Total	**21 credits**	

SEMESTER -6

Sl no	Course Code	Subjects	Credits	L-T-P
1	EN301	Art of Engineering Research	2	2-0-0
2		Multidisciplinary/Open Elective- 2/MOOC 1[$]	3	3-0-0
3	IT0XX	Department Elective-1	3	3-0-0
4	IT305	Game Theory	3	3-0-0
5	IT306	Machine Learning	4	3-0-2
6	IT307	Wireless Communication Technologies	4	3-0-2
		Total	**19 credits**	

BTech Project allocation to be done during 6th Semester

[$] MOOC 1 can also be taken in summer after 2nd semester if the student wishes to finish it earlier.

EXIT AFTER YEAR - 3 → **B.Sc. in Information Technology (129 credits)**

SEMESTER -7

Sl no	Course Code	Subjects	Credits	L-T-P
1		Multidisciplinary/Open Elective- 3/MOOC2[$]	3	3-0-0
2	IT0XX	Department Elective -2	3	3-0-0
3	IT404	Software Engineering	4	3-0-2
4	IT401	Cloud Computing	3	3-0-0
5	IT402	Digital Image Processing	4	3-0-2
6	IT403	Cryptography	3	3-0-0
7	IT399	BTech Summer Project	6	0-0-12
		Total	**26 credits**	

[$] MOOC 2 can also be taken in summer after 4th semester if the student wishes to finish it earlier

SEMESTER -8

Sl no	Course Code	Subjects	Credits	L-T-P
1	IT408	Deep Learning	3	3-0-0
2	IT405	Data Mining	4	3-0-2
3.	IT406	IoT and Applications	3	3-0-0
4.	IT407	Mobile Computing	3	3-0-0
5.	IT409	Blockchain Technologies	3	3-0-0
6		Multidisciplinary/Open Elective- 4/MOOC 3	3	3-0-0
		Total	**19 credits**	

Colloquium of 3 credits in summer semester (MOOC, NPTEL etc. in place of colloquium)

EXIT AFTER YEAR - 4 → **B.Tech.$/B.Sc. (Hons.)# in Information Technology (174 credits)**

SEMESTER -9

Sl no	Course Code	Course	Credits	L-T-P
1.	IT501	Natural Language Processing	4	3-0-2
2	IT0XX	Department Elective -3	3	3-0-0
3.	IT498	Colloquium (Based on industrial training)/MOOC	3	0-0-6
4.	IT598	MTech Thesis – Part 1	12	0-0-24
		Total	**22 credits**	

SEMESTER -10

Sl no	Course	Course	Credits	L-T-P
1.	IT0XX	Department Elective – 4/MOOC 4	3	3-0-0
2.	IT599	MTech Thesis – Part 2	12	0-0-24
		Total	**15 credits**	

FINAL EXIT AFTER YEAR – 5 → **B.Tech. + M.Tech. in Information Technology (211 credits)**

NOTE-1:

$ BTech. in Information Technology: If a candidate is allowed for an early exit after 4th year in the beginning of 4th year or termed as Planned Exit. In such a case the course structure is different form the above from 7th Semester. Please refer to the course structure of BTech. in Information Technology 7th semester onwards.

BSc (Honours) in Information Technology: If a candidate opts for an abrupt exit after 4th year without exercising an option for exit in the beginning of 3rd year or termed as Abrupt Exit. In such a case the student exits with BSc. in Information Technology.

Minor in Information Technology (Total 23 credits required)

Sl no	Code	Courses	Credits	L-T-P
1	IT207	Operating System	4	3-0-2
2	IT208	Computer Networks	4	3-0-2
3	IT404	Software Engineering	4	3-0-2
4	IT205	Database Systems	4	3-0-2
5	IT401	Cloud Computing	4	3-0-2
6	IT0XX	IT Elective Courses	3	3-0-0
		Total	**23 Credits**	

B.Tech. in Information Technology - 7th Semester onwards

(For students allowed for Early exit from IMT/IMG programs)

SEMESTER -7

Sl no	Course Code	Subjects	Credits	L-T-P
1		Multidisciplinary/Open Elective- 3/MOOC 2[$]	3	3-0-0
2	IT0XX	Department Elective -2	3	3-0-0
3	IT404	Software Engineering	4	3-0-2
4	IT401	Cloud Computing	3	3-0-0
5	IT402	Digital Image Processing	4	3-0-2
6	IT403	Cryptography	3	3-0-0
7	IT498	Colloquium (Based on industrial training)/MOOC 3	3	0-0-6/
		Total	**23 credits**	

[$] MOOC 2 can also be taken in summer after 4th semester if the student wishes to finish it earlier

SEMESTER -8

Sl no	Course Code	Subjects	Credits	L-T-P
1	IT499	BTech Project/Internship	12	0-0-24
2	IT0XX	Department Elective – 3/MOOC 4	3	3-0-0
		Total	**15 credits**	

FINAL EXIT AFTER YEAR - 4 → **B.Tech. in Information Technology (167 credits)**

Elective courses

1. Visual Information Processing

Sl.No	Course Name	Code	L-T-P	Credits
1	Computer Vision	IT001	3-0-0	3
2	Digital Signal Processing	IT002	3-0-0	3
3	Pattern Recognition	IT003	3-0-0	3
4	Information Retrieval and Extraction.	IT004	3-0-0	3
5	Human Computer Interaction	IT005	3-0-0	3
6	Digital Video Processing	IT006	3-0-0	3
7	Advanced Machine Learning	IT007	3-0-0	3
8	Multimedia Processing	IT008	3-0-0	3
9	Digital Watermarking	IT009	3-0-0	3
10	Applied Image Processing	IT010	3-0-0	3

2. Communication and Networks

Sl.No	Course Name	Code	L-T-P	Credits
1	Cognitive Radio	IT011	3-0-0	3
2	Next Generation Networks	IT012	3-0-0	3
3	Queuing Theory	IT013	3-0-0	3
4	Network design and Optimization	IT014	3-0-0	3
5	Advanced Wireless Communications	IT015	3-0-0	3
6	Multimedia Networks	IT016	3-0-0	3
7	Industrial IoT Communication	IT017	3-0-0	3
8	Detection and Estimation Theory	IT018	3-0-0	3

9	Distributed Systems	IT019	3-0-0	3
10	Information Theory and Coding	IT020	3-0-0	3
11	Convex Optimization	IT021	3-0-0	3

3. Information Security

Sl.No	Course Name	Code	L-T-P	Credits
1	Digital Watermarking and Steganalysis	IT022	3-0-0	3
2	Cryptography and Network Security	IT023	3-0-0	3
3	Distributed System Security	IT024	3-0-0	3
4	Cyber Security and Laws	IT025	3-0-0	3
5	Advanced cryptography	IT026	3-0-0	3
6	Information Security and Secure Coding	IT027	3-0-0	3
8	Malware Analysis	IT028	3-0-0	3
9	Formal methods for Security Verifications	IT029	3-0-0	3
10	IoT and its security	IT030	3-0-0	3
11	Blockchain Technologies	IT031	3-0-0	3

4. Computing and Data Sciences

Sl.No	Course Name	Code	L-T-P	Credits
1	Convex Optimization	IT032	3-0-0	3
2	Parallel and Concurrent Programming	IT033	3-0-0	3
3	Scientific Computing and Numerical	IT034	3-0-0	3
4	Optimization Techniques	IT035	3-1-0	4
5	Big Data Analytics	IT036	3-0-0	3
6	Integrated Circuit Technology	IT037	3-0-2	4
7	Program Analysis Verification and Testing	IT038	3-0-0	3
8	Competitive Programming	IT039	3-0-0	3
9	Microprocessor and Interfacing	IT040	3-0-2	4
10	Generative Artificial Intelligence	IT-719	3-0-0	3
11	Large Language Models	IT-720	3-0-0	3

NOTE-1:

[$] BTech. in Information Technology: If a candidate opts for an early exit after 4th year in the beginning of 3rd year or termed as Planned Exit.

[#]BSc (Honours) in Information Technology: If a candidate opts for an abrupt exit after 4th year without exercising an option for exit in the beginning of 3rd year or termed as Abrupt Exit. In such a case the student exits with BSc. in Information Technology.

Integrated Postgraduate in Business Administration (B.Tech. in IT + MBA) (227 credits)

SEMESTER -1

Sl no	Course Code	Subjects	Credits	L-T-P
1	EE101	Fundamentals of Electrical and Electronics	4	3-0-2
2	ES101	Engineering Physics	4	3-0-2
3	ES102	Engineering Mathematics	4	3-1-0
4	EE102	Engineering Design Principles	3	2-0-2
5	IT101	Principles of Computer Programming	4	3-0-2
6	HS101	Freshman Skills	2	2-0-0
7	HS102	Sports and Physical Education	2	0-1-2
		Total	**23 Credits**	

SEMESTER -2

Sl no	Course Code	Subjects	Credits	L-T-P
1	EE103	Digital Electronics	4	3-0-2
2	ES103	Probability and Statistics	4	3-1-0
3	IT102	Data Structures	4	3-0-2
4	EE104	Hardware Workshop	3	1-0-4
5	IT103	Object Oriented Programming	4	3-0-2
6	HS103	Ecology and Environment Sciences	2	2-0-0
7	CS104	Mobile Application Technologies	2	0-1-2
		Total	**23 Credits**	
	MO101	MOOC-1 (Optional in summer)	2/3-0-0	

EXIT AFTER YEAR - 1 → **Certificate in Engineering Sciences (46 credits)**

SEMESTER -3

Sl no	Course Code	Subjects	Credits	L-T-P
1	HS201	Indian Culture, Ethics and Moral Values	2	2-0-0
2	IT201	Discrete Structures	4	3-1-0
3	IT202	Computer Organization and Architecture	4	3-0-2
4	IT203	Design and Analysis of Algorithms	4	3-0-2
5	IT204	Data Communications	4	3-0-2
6	IT205	Database Systems	4	3-0-2
		Total	**22 credits**	

SEMESTER -4

Sl no	Course Code	Subjects	Credits	L-T-P
1	MS619	Entrepreneurship and Innovation	2	2-0-0
2	IT206	Theory of Computation	3	3-0-0
3	IT207	Operating Systems	4	3-0-2
4	IT208	Computer Networks	4	3-0-2
5	EE201	Signals and Systems	4	3-1-0
6	IT209	Graph Theory	4	3-0-2
		Total	**21 credits**	
	MO201	MOOC-2 (Optional in summer)	2/3-0-0	

EXITAFTER YEAR - 2 → **Diploma in Information Technology (89 credits)**

SEMESTER -5

Sl no	Course Code	Subjects	Credits	L-T-P
1	MS603	Business Economics	3	3-0-0
2		Multidisciplinary/Open Elective- 1	3	3-0-0
3	IT308	Nature Inspired Computing	3	3-0-0
4	IT302	Compiler Design	4	3-0-2
5	IT303	Computer Graphics	4	3-0-2
6	IT304	Trustworthy Artificial Intelligence	4	3-0-2
		Total	**21 credits**	

SEMESTER -6

Sl no	Course Code	Subjects	Credits	L-T-P
1	EN301	Art of Engineering Research	2	2-0-0
2		Multidisciplinary/Open Elective- 2/MOOC 1$	3	3-0-0
3	IT0XX	Department Elective-1	3	3-0-0
4	IT309	Game Theory	3	3-0-0
5	IT306	Machine Learning	4	3-0-2
6	IT307	Wireless Communication Technologies	4	3-0-2
		Total	**19 credits**	

BTech Project allocation to be done during 6th Semester

$ MOOC 1 can also be taken in summer after 2nd semester if the student wishes to finish it earlier.

EXIT AFTER YEAR - 3 → **B.Sc. in Information Technology (129 credits)**

$ MOOC 2 can also be taken in summer after 4th semester if the student wishes to finish it earlier Colloquium of 3 credits in summer semester (MOOC, NPTEL etc. in place of colloquium)

SEMESTER - 7

Sl no.	Course Code	Subject	Credits	L-T-P
1	MS601	Principles and Practices of Management	3	3-0-0
2	MS604	Business and Legal Environment	3	3-0-0
3	MS605	Financial Reporting and Control	3	3-0-0
4	MS606	Organizational Behavior	3	3-0-0
5	MS607	IoT and Big Data Management	3	2-0-2
6	MS617	Business Data Mining	3	2-0-2
7	IT404	Software Engineering	4	3-0-2
8	MS0XX	**Department Elective-I**	**3**	**3-0-0**
9	MS399	BTech Summer Project	6	0-0-12
		Total	**31 Credits**	

SEMESTER - 8

Sl no.	Code	Title of the Course	Credits	L-T-P
1	MS610	Operations Management	3	3-0-0
2	MS611	Marketing Management	3	3-0-0
3	MS612	Financial Engineering and Management	3	3-0-0
4	MS613	Business Research Methods	3	3-0-0
5	MS622	Could Computing and Services	3	2-0-2
6	MS0XX	**Department Elective-II**	**3**	**3-0-0**
7		Multidisciplinary/Open elective/ MOOC-1	3	3-0-0
8	MS596	Mini project	3	0-0-6
		Total	**24 Credits**	

Colloquium of 4 credits in summer semester (MOOC, NPTEL etc. in place of colloquium)

ABRUPT EXIT AFTER 4 YEARS → **B.Sc. in Information Technology (IT) + One year Diploma in Management (184 credits)**

SEMESTER - 9

Sl no.	Course Code	Title of the Course	Credits	L-T-P
1	MS618	Strategic Management	3	3-0-0
2	MS620	Business Process Management	3	3-0-0
3	MS621	Business Ethics and Sustainability	3	3-0-0
4	MS0XX	**Department Elective-III**	3	3-0-0
5	MS0XX	**Department Elective-IV**	3	3-0-0
6		Multidisciplinary/Open elective/ MOOC-2	3	3-0-0
	MS597	Colloquium (Based on industrial training)/MOOC	4	0-0-8
7	MS598	Major Thesis Part- 1	6	0-0-12
		Total	**28 Credits**	

SEMESTER - 10

Sl no.	Course Code	Title of the Course	Credits	L-T-P
1		Multidisciplinary/Open elective/ MOOC-3	3	3-0-0
2	MS599	Major Thesis Part- 2	12	0-0-24
		Total	**15 Credits**	

FINAL EXIT AFTER 5 YEARS → **B.Tech. in Information Technology + MBA (227 credits)**

List of electives proposed to be offered in Odd and Even Semesters

Specialization Basket 01: Information Technology and Systems

Sl no.	Course Code	Subject	L-T-P	Credits	Semester
1	MS001	Digital Production System	3-0-0	3	Odd
2	MS002	IT Products and Intellectual Property Rights	3-0-0	3	Even
3	MS003	Management of Digital Technologies	3-0-0	3	Odd
4	MS004	Knowledge Management	3-0-0	3	Even
5	MS005	Service-Oriented Computing	3-0-0	3	Odd
6	MS006	Social Networks Analytics	3-0-0	3	Even
7	MS007	Software Project Management	3-0-0	3	Odd
8	MS008	Software Quality Management	3-0-0	3	Even
9	MS009	Programming for Business Intelligence	3-0-0	3	Odd
10	MS010	Strategic Planning of Information Systems	3-0-0	3	Even

Specialization Basket 02: Technology and Operations Management

Sl no.	Course Code	Subject	L-T-P	Credits	Semester
1	MS011	Business Systems Simulation	3-0-0	3	Odd
2	MS012	Service Operations Management	3-0-0	3	Even
3	MS013	Sustainable Supply Chain Management	3-0-0	3	Odd
4	MS014	Technology Management	3-0-0	3	Even
5	MS015	Technology and Operations Strategy	3-0-0	3	Odd

6	MS016	Total Quality Management	3-0-0	3	Even
7	MS017	World Class Production Systems	3-0-0	3	Odd
8	MS018	Emerging Areas in Technology and Operations	3-0-0	3	Even
9	MS019	New Products and Services Development	3-0-0	3	Odd
10	MS020	Project Management	3-0-0	3	Even

Specialization Basket 03: Human Resource Management

Sl no.	Course Code	Subject	L-T-P	Credits	Semester
1	MS021	Compensation Management	3-0-0	3	Odd
2	MS022	Change Management	3-0-0	3	Even
3	MS023	Corporate Social Responsibility	3-0-0	3	Odd
4	MS024	Competency Management	3-0-0	3	Even
5	MS025	Human Resource Information System	3-0-0	3	Odd
6	MS026	Emerging Areas in Human Resource	3-0-0	3	Even
7	MS027	Organization Theory and Development	3-0-0	3	Odd
8	MS028	Leadership and Talent Management	3-0-0	3	Even
9	MS029	Training and Development	3-0-0	3	Odd
10	MS030	Management of Employee Relations	3-0-0	3	Even

Specialization Basket 04: Finance

Sl no.	Course Code	Subject	L-T-P	Credits	Semester
1	MS031	Corporate Restructuring	3-0-0	3	Odd
2	MS032	Corporate Tax Planning	3-0-0	3	Even
3	MS033	Economic and Financial Modeling	3-0-0	3	Odd
4	MS034	Entrepreneurial Finance	3-0-0	3	Even
5	MS035	Management of Financial Services	3-0-0	3	Odd
6	MS036	Financial Risk management	3-0-0	3	Even
7	MS037	Personal Wealth Management	3-0-0	3	Odd
8	MS038	International Finance	3-0-0	3	Even
9	MS039	Project Appraisal and Finance	3-0-0	3	Odd
10	MS040	Security Analysis and Portfolio Management	3-0-0	3	Even

Specialization Basket 05: Marketing Management

Sl no.	Code	Subject	L-T-P	Credits	Semester
1	MS041	Consumer Behavior	3-0-0	3	Odd
2	MS042	Advertisement and Sales Promotion	3-0-0	3	Even
3	MS043	Product and Brand Management	3-0-0	3	Odd
4	MS044	E-marketing	3-0-0	3	Even
5	MS045	Retail Management	3-0-0	3	Odd
6	MS046	International Marketing	3-0-0	3	Even
7	MS047	Sales and Distribution	3-0-0	3	Odd
8	MS048	Marketing Research	3-0-0	3	Even
9	MS049	Service Marketing	3-0-0	3	Odd
10	MS050	Strategic Marketing	3-0-0	3	Even

Specialization Basket 06: Management of Social Sector

Sl no.	Code	Subject	L-T-P	Credits	Semester
1	MS051	Public Policy and Processes	3-0-0	3	Odd
2	MS052	Public Private Partnerships	3-0-0	3	Even
3	MS053	Sustainable Development	3-0-0	3	Odd
4	MS054	Management of Rural and Social Sector	3-0-0	3	Even
5	MS055	Information Technology Enabled Services	3-0-0	3	Odd
6	MS056	Management of Non-Formal Organization	3-0-0	3	Even
7	MS057	Healthcare System Management	3-0-0	3	Odd
8	MS058	Emerging Areas in Management of Social Sector	3-0-0	3	Even
9	MS059	Infrastructure Management	3-0-0	3	Even

List of Core courses for Minor in Management					
Sl	**Code**	**Title of the Course**	**L-T-P**	**Credits**	**Semester**
1	MS601	Principles and Practices of Management	3-0-0	3	Odd
2	MS605	Financial Reporting and Control	3-0-0	3	Odd
3	MS606	Organizational Behavior	3-0-0	3	Odd
4	MS607	IoT and Big Data Management	2-0-2	3	Odd
5	MS617	Business Data Mining	3-0-0	3	Odd
6	MS610	Operations Management	3-0-0	3	Even
7	MS611	Marketing Management	3-0-0	3	Even
8	MS612	Financial Engineering and Management	3-0-0	3	Even
9	MS613	Business Research Methods	3-0-0	3	Even
10	MS622	Could Computing	3-0-0	3	Even
List of Elective courses for Minor in Management					
S. No	**Course**	**Title of the Course**	**L-T-P**	**Credits**	**Semester**
1	MS001	Digital Production System	3-0-0	3	Odd
2	MS006	Social Networks Analytics	3-0-0	3	Even
3	MS013	Sustainable Supply Chain Management	3-0-0	3	Odd
4	MS012	Service Operations Management	3-0-0	3	Even
5	MS028	Leadership and Talent Management	3-0-0	3	Odd
6	MS022	Change Management	3-0-0	3	Even
7	MS035	Management of Financial Services	3-0-0	3	Odd
8	MS040	Security Analysis and Portfolio Mgt.	3-0-0	3	Even
9	MS049	Service Marketing	3-0-0	3	Odd
10	MS048	Marketing Research	3-0-0	3	Even

CODE WITH HSxxx

1	**Code of the subject**	HS101
2	**Title of the subject**	Freshman Skills
3	**Any prerequisite**	No
4	**L-T-P**	2-0-0
5	**Learning Objectives**	To improve their Personal Skills and Attributes, Study Skills and academic preparation, and learn Community Service.
6	**Brief Contents**	Personal Skills and Attributes Focus: Self-Awareness, Self-Management, and Character Development, Institute personnel and available services, the rotating schedule, acceptable use of social media, opportunities for involvement in extracurricular clubs and sports, effective time-management skills, positive character traits, building self-awareness. Study Skills and Academic Preparation Focus: The Principles of Learning, Establishing Strong Study Skills, Developing an Academic, Pathways, Personal Goals, identify personal post-secondary goals, inherent aptitudes, exploring post-secondary options, academic requirements for future goals, financial requirements for future goals, local and global economics, societal trends, cultural trends, Possible linguistic needs, transferable skills, resume foundations
7	**Text /references**	

1	**Code of the subject**	• HS102
2	**Title of the subject**	• Sports and Physical Education
3	**Prerequisite**	• No
4	**L-T-P**	• 0-1-2
5	**Learning Objectives**	• Students will get knowledge and understanding of the facts, concepts and practice relating to a range of sports-both indoor and outdoor. • To teach the students how to keep them fit, to increase his/her concentration, team coordination ability, which will help them as a professional.
6	**Brief Contents**	• he course will be taught in two components • Theory, Sport History, Human Anatomy, Stress Management/ Meditation/Yoga, Important tournaments and its players, Rules and Field Requirements, Sport Equipment, Sports Psychology, Role of IT in sports
7	**Contents for Field Sessions**	• Indoor/ Outdoor: Cricket/ Football/ Volleyball/ Basketball/Badminton/ Table-Tennis/ Lawn-Tennis/ Athletics/ Yoga

8	**Text/references**	• Nation at Play: Ronojoy Sen • The Art of Captaincy: What Sports teaches us about Leadership by Mike Brearley • The Anatomy of Exercise and Movement for the Study of Dance, Pilates, Sports, and Yoga by Jo Ann Staugaard-Jones • Stress and Its Management by Yoga, by K.N. Udupa, R.C. Prasad • THE WINNING WAY: Learning from Sport for Managers by Anita Bhogle, Harsha Bhogle • Think Like a Champion by Webster, Rudi V. • Attitude is Everything, by Jeff Keller

1	**Code of the subject**	HS103
2	**Title of the subject**	Ecology and Environment Sciences
3	**Prerequisite**	No
4	**L-T-P**	2-0-0
5	**Learning Objectives**	Upon course completion, students will be able to: 1. Understand the basic principles of ecology and ecosystem function. 2. Describe the interrelationships between land, sea, the atmosphere, and the living things that occupy these environments. 3. Determine the role that humans play in affecting the characteristics of the environment. 4. Evaluate current environmental issues and problems including the solutions and management practices that have been used or offered to address these issues and problems.
6	**Brief Contents**	**Environment and Human Intervention** Environment: Definition, environment and ecology, importance of environment, need of public awareness, sustainable ecosystem, human activities, and environment- agriculture, transport, mining, Environmental Impact Assessment (EIA) **Environmental Pollution** Water pollution, waste-water treatment- case studies, land pollution, air pollution, noise pollution, Pollution and public health issues, pollution and environment, greenhouse effect **Environment Protection Policies** Environment policies, forests, biosphere reserves, flora and wildlife, environment laws/acts, environmental movements, environment ethics and awareness, role of government and non-government organizations, introduction to GST-CGST and SGST, Swachh Bharat Abhiyan- initiatives, responsibilities and future aspects, Cash-less economy-modes of payment-money transfer (advantages and disadvantages), Making in India concept. **Applied issues in Ecology** Sustainability, habitant degradation, degradation of urban and industrial landscape, conservation, threats to biodiversity, evolutional ecology

7	**Contents for lab**	NA
8	**Text /references**	1. Townsend, C.R., Begon, M. and Harper, J.L., 2003. *Essentials of ecology* (Ed. 2). Blackwell Science. 2. R. Rajagopalan, 2011. *Environmental Studies*, Oxford IBH Pub. 3. Martell, L., 2013. *Ecology and Society: An introduction.* John Wiley & Sons.

1	**Code of the subject**	HS201
2	**Title of the subject**	Indian culture, Ethics and Morale
3	**Prerequisite**	No
4	**L-T-P**	2-0-0
5	**Learning Objectives**	Upon course completion, students will be able to: 1. Identify and analyze an ethical issue in the subject matter under investigation or in a relevant field. 2. Articulate what makes a particular course of action ethically defensible. 3. Assess their own ethical values and the social context of problems. 4. Evaluate the concept of karma that helps to maintain work life balance. 5. Demonstrate contemporary approaches to leadership who inspires human being to reach their goals
6	**Brief Contents**	**Human Values and Ethics** Morals, values and ethics-integrity, work ethics, service learning, civic virtue, respect for others, living peacefully, caring, sharing, honesty, courage, cooperation, commitment, empathy, self-confidence, character, spirituality. **Work Ethos and Values** Meaning of work ethos, levels, dimensions, steps, factors responsible for poor work ethos. Meaning of values, features, values for Indian managers, relevance of value-based management in global change, impact of values on stakeholders: employees, customers, government, competitors and society, values for managers, trans-cultural human values in management and management education, secular v/s spiritual values in management, importance of value system in work culture **Indian Ethos-An Overview** Meaning, features, need, history, relevance, principles practised by Indian companies, requisites, elements, role of Indian ethos in managerial practices, management lessons from Vedas, Mahabharata, Bible and Quran. **Contemporary Approaches to Indian Ethos** Contemporary approaches to leadership, joint Hindu family business, leadership qualities of karta, Indian systems of learning - gurukul system of learning, advantages-disadvantages of karma, importance of karma to managers, nish kama karma, laws of karma, law of creation, law of humility,

		law of growth, law of responsibility, law of connection, corporate karma leadership.
7	**Contents for lab**	NA
8	**Text /references**	1. Khandelwal, N. M., 2011. *Indian Ethos and Value for Management.* Himalaya Publishing House, 1st Edition. 2. Govindarajan, M., Natarajananad, S., SenthilKumar V.S., 2009. *Engineering Ethics includes Human Values.* PHI Learning Pvt. Ltd. 3. Nandagopal R., Ajith Rn., 2010. *Indian Ethos and Values in Management*. Tata McGraw Hill Education, 1st Edition. 4. Murthy, P.S.R., 2013. *Indian Culture, Values and Professional Ethics*. BS Publication

CODE WITH CSxxx

1	**Code of the subject**	CS101
2	**Title of the subject**	Principles of Computer Programming
3	**Prerequisite**	No
4	**L-T-P**	3-0-2
5	**Learning Objectives**	To understand the basic principles of programming languages. To provide design & development of C and Python programming skills. To introduce problem solving methods and program development.
6	**Brief Contents**	Basics of Computer Languages C, Compilers, Interpreter, Programming Environments and Debugging: types of errors and debugging techniques. Programming features: Data types, Expressions and Operators, Control statements, Iterations. Functions: Scope of variables, call by value, call by reference, Recursion, Pointers. Array, String, Structures and Unions. File handling, File redirection, File pointers. Applications of C programming concepts in different data structures. Python: Introduction, Program Organization, Functions, Modules and Libraries.
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**Text/references**	1. Kernighan, B.W. and D. M. Ritchie (1998): The C programming language, 2nd ed. Prentice Hall of India. 2. Kanetkar, Y (2016): Let us C, 15thed .BPB Publications. 3. King K.N (2008): C Programming: A Modern Approach. 2nd ed. W. W. Norton & Company.

1	**Code of the subject**	CS102
2	**Title of the subject**	Data Structures
3	**Prerequisite**	Principles of Computer Programming
4	**L-T-P**	3-0-2
5	**Learning Objectives**	To understand the basic data structures and algorithms for performing operations on data structures, the use of data structures to provide efficient software solutions, and some algorithm paradigms for building efficient algorithms.
6	**Brief Contents**	Introduction to Abstract data types, linear and linked data structures – Arrays, Stacks, Queues, Linked List. Introduction to searching and sorting algorithms –Quick sort, Merge sort, Heap sort, linear time sorting; evaluation of infix/postfix expressions. Trees, binary search trees and basic operations, AVL trees, heaps, hash tables. Algorithm analysis: time and space complexity, asymptotic behavior, estimating runtime, comparison of algorithms. Graphs and basic algorithms on graphs: depth first and breadth first search, Dijkstra‘s algorithm. Hash Tables

7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**Text/references**	1. Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein. 2009. Introduction to Algorithms, Third Edition (3rd ed.). The MIT Press. 2. Steven S. Skiena. 2008. The Algorithm Design Manual (2nd ed.). Springer Publishing Company, Incorporated.

1	**Code of the subject**	CS103
2	**Title of the subject**	Object Oriented Programming
3	**Prerequisite**	Programming concepts
4	**L-T-P**	3-0-2
5	**Learning Objectives**	To develop programming skill and to solve engineering related
6	**Brief Contents**	Object oriented thinking: Need for OOP Paradigm, Procedural programming vs object oriented programming, object oriented concepts. Class and object concepts: Difference between C structure and class, specifying a class, Defining members inside and outside class, etc. Constructor and destructor concepts, Operator overloading and Type Conversion, Inheritance and polymorphism concepts Working with files: Classes for file stream operations, opening and closing files, File opening modes, file Pointers, Error handling during file operations, command line arguments. Templates: Class template, class template with parameter, function template, function template with parameter and Exception handling
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**List of text books/references**	1. HM Deitel and PJ Deitel ―C++ How to Program, Seventh Edition, 2010, Prentice Hall. 2. Brian W. Kernighan and Dennis M. Ritchie, ―The C programming Language, 2006, Prentice-Hall. 3. E Balagurusamy, ―Object oriented Programming with C++, Third edition, 2006, Tata McGraw Hill. 4. Bjarne Stroustrup, ―The C++ Programming language, Third edition, Pearson Education. 5. Horstmann ―Computing Concepts with C++ Essentials,Third Edition,2003, John Wiley. 6. Robert Lafore, ―Object Oriented Programming in C++, 2002, Pearson education.

1	**Code of the subject**	CS104
2	**Title of the subject**	Mobile Application Technologies
3	**Prerequisite**	No
4	**L-T-P**	0-1-2

5	**Learning Objectives**	To develop the basic skills of using Android IDE and Android SDK for implementing Android applications
6	**Brief Contents**	Introduction, UX development, Testing and debugging of front end and back end application components and their interaction.
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**Text /references**	1. Android Programming: The Big Nerd Ranch Guide 4th Edition, Bill Phillips, Brian Hardy 2. The Busy Coder's Guide to Android Development, Mark Murphy.

1	**Code of the subject**	CS201
2	**Title of the subject**	Discrete Structures
3	**Prerequisite**	Engineering Mathematics
4	**L-T-P**	3-1-0
5	**Learning Objectives**	To prepare for a background in abstraction, notation, and critical thinking for the mathematics most directly related to computer science. To foster rigorous thinking skills that can enhance the quality of work of computing professionals. To relate and apply these concepts to practical applications of computer science.
6	**Brief Contents**	Fundamentals of Logicand their use in program proving, resolution principle. Set Theory and Functions, Graph Theory, Group Theory, Elementary Combinatorics etc.
7	**Text/references**	1.Bernanrd Kolman, Robert C Busby, S.Ross, Discrete Mathematical Structures, PHI Learning 2. Kenneth H. Rosen, Discrete Mathematics and Its Appications, Tata McGraw-Hill Edition 3. I.N. Herstein, Topics in Algebra, John Wiley Publications 4. Ralph P. Grimaldi, B.V. Ramana, Discrete and Combinatorial Mathematics, Pearson Education

1	**Code of the subject**	CS202
2	**Title of the subject**	Computer Organisation and Architecture
3	**Any prerequisite**	Digital Electronics, Principles of computer programming
4	**L-T-P**	3-0-2
5	**Learning Objectives**	To understand the Organization and architecture aspects of
6	**Brief Contents**	Basic functional blocks of a computer, introduction to Instruction set architecture of a CPU and instruction sets of some common CPUs. Data representation, Computer arithmetic, Control unit design, Memory system, Peripheral devices and their characteristics, Performance enhancement techniques Pipelining, Memory organization.

7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**Text/references**	1. Computer Organization and Design: The Hardware/Software Interface, David A Patterson, John L. Hennessy, 4th Edition, Morgan Kaufmann. 2. Computer Architecture and Organization by William Stallings, PHI Pvt. Ltd., Eastern Economy Edition.

1	**Code of the subject**	CS203
2	**Title of the subject**	Design and Analysis of Algorithms
3	**Prerequisite**	Data Structures, Principles of Computer Programming, Engineering Mathematics
4	**L-T-P**	3-0-2
5	**Learning Objectives**	To understand the performance aspects of algorithms in programming the computing systems
6	**Brief Contents**	Introduction, Asymptotic complexity, Searching in list, Concepts of graphs and shortest path estimation algorithms, Divide and conquer approaches, Search Trees, Greedy : Interval scheduling, Greedy :Proof strategies,Greedy : Human coding, Dynamic Programming: weighted interval scheduling Dynamic Programming, Intractability: NP completeness, Intractability :reductions and examples
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**Text/references**	1. Introduction to Algorithms (Eastern Economy Edition) by Thomas H Cormen and Charles E Leiserson. 2. Design and Analysis of Algorithms by S Sridhar. 3. Design and Analysis of Computer Algorithms by AHO.

1	**Code of the subject**	CS204
2	**Title of the subject**	Database Systems
3	**Prerequisite**	No
4	**L-T-P**	3-0-2
5	**Learning Objectives**	To understand a Database application, the design and performance aspects from the perspective of Database systems of the past, present and future.
6	**Brief Contents**	Introduction to Databases, Relational Data Model, Relational Algebra, SQL and NoSQL concepts, Database Normalization, Indexing, Database Transactions, Recovery Systems, Transaction Schedules, Concurrency Control, Query Processing and Query Optimization.
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications

8	**Text /references**	1. Abraham Silberschatz, Henry Korth, and S. Sudarshan. Database Systems Concepts (5ed.). McGraw-Hill, New York, USA. 2. Ramez A. Elmasri, Shankrant B. Navathe. Fundamentals of Database Systems Addison-Wesley Longman Publishing Co. 3. Paul DuBois. Mysql. New Riders Publishing 4. C. J. Date. Database in Depth: Relational Theory for Practitioners. O'Reilly Media, Inc. 5. Bipin C. Desai. An Introduction to Database Systems. West Publishing Co.

1	**Code of the subject**	CS205
2	**Title of the subject**	Paradigms of Programming Languages
3	**Prerequisite**	Principles of Computer Programming, Object Oriented Programming
4	**L-T-P**	3-0-2
5	**Learning Objectives**	To understand the key principles of programming language paradigms, compare and contrast the advantages and disadvantages of the imperative and functional programming paradigms, describe the compilation principles and highlight modern trends' impact on programming languages.
6	**Brief Contents**	The role and for programming languages, characteristics; Programming language paradigms, Language designand translation issues; Properties of data types and objects, type conversion, binding and binding times. Procedures Sequence Control, Subprogram control, desirable and undesirable characteristics of procedural programming. Case study of Pascal. Functional Programming Paradigm, Declarative Programming Paradigm, Parallel Programming Paradigm, Classification of computer architectures, principles of parallel programming, precedence graph, data parallelism, control parallelism, message passing, shared address space, synchronization mechanisms, mapping, granularity, compilers, operating systems; Additional Programming Paradigms Data flow programming design principles, Database programming design principles, Network programming design principles, Socket programming in JAVA, Internet programming design principles etc.
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**Text/references**	1. RoostaSeyed, “Foundations of Programming Languages Design & Implementation”, Cenage learning. 2. Pratt T.W., Zelkowitz “Programming Languages: Design and Implementation” PHI 3. Programming Language Design Concepts, D. A. Watt, Wiley India Edition. Reference Books: 1. Sebesta R. W., “Concepts of programming languages”, Pearson Education 2001, 4th edition. 2. Sethi Ravi, “Programming Languages: Concepts and Constructs” Pearson Education,

		3. Herbert Schildt "The Complete Reference Java2", 5th edition, Tata McGraw Hill.

1	**Code of the subject**	CS206
2	**Title of the subject**	Theory of Computation
3	**Prerequisite**	No
4	**L-T-P**	3-0-0
5	**Learning Objectives**	To introduce the mathematical foundations of computation, develop the ability to understand and conduct mathematical proofs for computation and algorithms.
6	**Brief Contents**	Finite Automata, Finite State system concepts, Regular Languages, Equivalence of NFA and DFA, Minimization of DFA- – Pumping Lemma for Regular. Grammars, Pushdown Automata, Turing Machines, Unsolvable Problems and Computable functions, Measuring and classifying complexity: Tractable and Intractable problems- Tractable and possibly intractable problems – P and NP completeness – Polynomial time reductions.
7	**Text /references**	1. Hopcroft J.E., Motwani R. and Ullman J.D, ―Introduction to Automata Theory, Languages and Computations, Pearson Education. 2. John C Martin, ―Introduction to Languages and the Theory of Computation, TMH, New Delhi. REFERENCES 1.Mishra K L P and Chandrasekaran N, ―Theory of Computer Science – Automata, Languages and Computation, Third Edition, Prentice Hall of India 2.Harry R Lewis and Christos H Papadimitriou, ―Elements of the Theory of Computation, Second Edition, Prentice Hall of India, Pearson Education, New Delhi. 3.Peter Linz, ―An Introduction to Formal Language and Automata, Third Edition, Narosa Publishers. 4.KamalaKrithivasan and Rama. R, ―Introduction to Formal Languages, Automata Theory and Computation, Pearson Education.

1	**Code of the subject**	CS207
2	**Title of the subject**	Operating Systems
3	**Prerequisite**	Computer Organization; Data Structures and Computer Programming
4	**L-T-P**	3-0-2
5	**Learning Objectives**	To study the importance of the operating system and its function, techniques of the operating system to achieve its goals as resource manager. Application interaction with the operating system and the operating systems interaction with the machine.

6	**Brief Contents**	Introduction and history of Operating systems, Process concepts and scheduling, Storage management, Processor management, Interprocess communication, CPU scheduling, Process Synchronization, Memory Management, Virtual memory concepts, Deadlocks, Device management, File management, File Systems, Free space Management: Bit vector, Linked list. Some case Studies of traditinal and modern operating systems.
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**Text /references**	1. A. Silberschatz & P.B. Galvin, Operating System concepts and principles, Wiley India. 2. A. Tanenbaum, Modern Operating Systems', Prentice Hall India 3. W. Stallings, _Operating Systems: Internals and design Principles, Pearson Ed. 4. M.J. Bach, Design of Unix Operating system', Prentice Hall. Additional Reading: 1. D.M. Dhamdere, Operating Systems: a concept based approach', Tata McGraw-Hill Pubs. 2. G. Glass, Unix for programmers and users-a complete guide, Pearson Ed.

1	**Code of the subject**	CS208
2	**Title of the subject**	Computer Networks
3	**Prerequisite**	User applications and some aspects of process and their interaction
4	**L-T-P**	3-0-2
5	**Learning Objectives**	The understand the purpose and overview of the Internetworking technology, issues, and approaches using top-down philosophy.
6	**Brief Contents**	Computer Networks and the Internet, Network Application Architectures, Processes Communication, Transport Services, Application-Layer Protocols, The Web and HTTP, Case Study: P2P Internet Telephony with Skype, Socket Programming with TCP and UDP; Transport Layer: Relationship Between Transport and Network Layers, Overview of the Transport Layer in the Internet, Principles of Reliable Data Transfer Services, Multiple Access protocols, Link-Layer concepts; Wireless and Mobile Networks, Cellular Internet Access, Mobile IP.
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**Text /references**	Computer Networking: A top-down approach featuring the Internet / James F. Kurose , Keith W. Ross., 7th edition, Pearson.

1	**Code of the subject**	CS209
2	**Title of the subject**	Mathematical Foundations of Computing
3	**Prerequisite**	Nil
4	**L-T-P**	3-1-0

5	**Learning Objectives**	To model computer science domain problems mathematically, think abstractly and employ techniques to study the properties.
6	**Brief Contents**	Induction, Propositional predicate logic, First order logic, Proof techniques and applications, Linear programming, Series divergence/convergence, Fourier Series/Transform, number theory etc.
7	**Text /references**	1. Donald F. Stanat and David F. McAllister, Discrete mathematics in Computer Science. 2. Thomas Koshy, Elementary number theory with Applications, Elsevier 3. I. N. Herstein, Topics in Algebra. JOHN Wiley & SONS. 4. Simulyan, First Order Logic

1	**Code of the subject**	CS210
2	**Title of the subject**	Software Engineering
3	**Prerequisite**	No
4	**L-T-P**	3-0-2
5	**Learning Objectives**	To impart software engineering concepts helpful for designing software systems for standalone and networked applications.
6	**Brief Contents**	Introduction, Software development process, project management process. Software requirement Analysis and specification; Software planning, Software design, Verification and validation techniques, Software quality and reliability, System Reliability and Reliability measures
7	**Contents for lab**	Use of software design tools (UML etc.) for design, software applications design and testing on vrious application centric measures, Fintech software design etc.
8	**Text /references**	1. Pham, Hoang. System software reliability. Springer Science & Business Media, 2007. 2. Jalote Pankaj, An Integrated Approach to Software Engineering, Narosa Publishing House 3. Pressman, Roger S., Software Engineering : A practitioner‘s Approach, McGraw-Hill, Inc.

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1	**Code of the subject**	CS301
2	**Title of the subject**	Compiler Design
3	**Prerequisite**	Theory of Computation
4	**L-T-P**	3-0-2
5	**Learning Objectives**	To design the front end of the compiler, scanner, parser, intermediate code generator, objectcode generator, and the parallel compilation strategies. To gain the ability to implement a parser etc.
6	**Brief Contents**	The structure of Compiler – Lexical analysis, Syntax analysis, LR parsers; Intermediate code generation concepts, Object code generation, Code optimization, Parallelizing compiler etc.
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**Text /references**	1. Alfred V. Aho, Monica S.Lam, Ravi Sethi, Jeffrey D.Ullman, Compilers : Principles, Techniques and Tools, Second Edition, Pearson Education. 2. Randy Allen, Ken Kennedy, Optimizing Compilers for Modern Architectures: A Dependence-based Approach, Morgan Kaufmann Publishers. 3. Steven S. Muchnick, Advanced Compiler Design and Implementation‖, Morgan Kaufmann Publishers - Elsevier Science, India, Indian Reprint. 4. Keith D Cooper and Linda Torczon, Engineering a Compiler, Morgan Kaufmann Publishers Elsevier Science. 5. V. Raghavan, Principles of Compiler Design, Tata McGrawHill Education Publishers.

1	**Code of the subject**	CS302
2	**Title of the subject**	Computer Graphics
3	**Prerequisite**	No
4	**L-T-P**	3-0-2
5	**Learning Objectives**	To expose onto the primary tools by which the flood of information from Computational Science is analyzed.
6	**Brief Contents**	Introduction of computer graphics, Graphic Displays and the algorithms; Three Dimensional aspects of graphics; Transformations; Windowing and Clipping concepts; Hidden Lines and Surfaces etc.
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**List of text books/references**	1.Computer Graphics, C Version Donald D Hearn, M. Pauline Baker 2. Computer Graphics: Principles and Practiceby James D. Foley, Andries van Dam , Steven K. Feiner

1	**Code of the subject**	CS303
2	**Title of the subject**	Trustworthy Artificial Intelligence
3	**Prerequisite**	No
4	**L-T-P**	3-0-2
5	**Learning Objectives**	To understand the techniques and concepts related to machine based reasoning systems through various applications of AI
6	**Brief Contents**	Introduction to AI and intelligent agents. Problem solving methods in AI, Informed and uninformed search strategies, knowledge representation, Uncertain Knowledge and Reasoning, Probabilities, Bayesian Networks. Overview of different forms of learning, Learning Decision Trees, Artificial Neural Networks and Fuzzy Approaches; Logic in AI, Prolog, Modern AI language and tools etc.
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**Text /references**	1. S. Russell and P. Norvig, Artificial Intelligence: A Modern Approach, 2nd Ed, Prentice Hall, 2003 2. Elaine Rich and Kevin Knight. Artificial Intelligence, Tata McGraw Hill Reference Books: 1. Patrick Henary Winston, Artificial Intelligence, Pearson publication 2. Deepak Khemani. A First Course in Artificial Intelligence, McGraw Hill Education (India) 3. Eugene Charnaik and Drew McDermott, Introduction to Artificial Intelligence, Pearson publication 4. Nils John Nilsson, The Quest for Artificial Intelligence: A History of Ideas and Achievements, Morgan Kaufman 5. Dennis Rothman, Artificial Intelligence by Example

1	**Code of the subject**	CS304
2	**Title of the subject**	Data Analytics and Visualisation
3	**Prerequisite**	No
4	**L-T-P**	3-0-0
5	**Learning Objectives**	1. Provide an overview of the statistical tools used to process, analyse, and visualize data. 2. Form testable hypotheses that can be evaluated using common statistical analyses.
6	**Brief Contents**	Introduction to the science of statistics: Fundamental elements of Statistics, Qualitative and Quantitative Data Summaries, Normal distribution, Sampling, Central Limit Theorem. Confidence intervals and hypothesis tests: Statistical Inference, Stating Hypotheses, Test Statistics and p-Values, Evaluating Hypotheses, Significance Tests and Confidence Intervals, Inference about a Population Mean, Two-Sample Problems Parametric association: Scatterplots, Correlation, Simple Linear Regression, F-test for Simple Linear Regression, t-test for Simple Linear Regression.

		Multiple linear regression: Equation of multiple linear regression, Interpretation of multiple linear regression, F-test for Multiple Linear Regression, t-tests in Multiple Linear Regression, Cautions about Regression Analysis of Variance (ANOVA): One-Way Analysis of Variance, F-test for ANOVA, Evaluating Group Differences, Type I and Type II Errors, Issues with Multiple Comparisons, Assumptions of Analysis of Variance, Relationship between One-Way ANOVA and Regression, One-Way Analysis of Covariance, Two-Way Analysis of Variance, Two-Way Analysis of Covariance Analysis for proportions: One-Sample Tests for Proportions, Significance Tests for a Proportion, Confidence Intervals for a Proportion, Two-Sample Tests for Proportions, Confidence Intervals for Differences in Proportions, Significance Tests for Differences in Proportions, Effect Measures, Logistic Regression, Multiple Logistic Regression, Area under the ROC Curve.
7	**Contents for lab**	Implementation of data analytics methods using R or Python.
8	**Text books/references**	1. Andy Field, Jeremy Miles and Zoe Field, "Discovering Statistics Using R", SAGE Publications Ltd (2012). 2. Gareth James, Daniela Witten, Trevor Hastie and Robert Tibshirani "An Introduction to Statistical Learning with Applications in R", Springer (2013).

1	**Code of the subject**	CS305
2	**Title of the subject**	Nature Inspired Computing
3	**Prerequisite**	Engineering mathematics, programming
4	**L-T-P**	3-0-0
5	**Learning Objectives**	To equip with the engineering problem formulation skills and optimization approaches to solve the problems along with quantitative analysis of those.
6	**Brief Contents**	Fundamentals of optimization, covering convex sets, convex functions, optimality conditions, and classical convex optimization methods; Evolutionary algorithms; swarm intelligence techniques; physics/chemistry inspired techniques
7	**List of text books/references**	Eiben, A. E., & Smith, J. E. (2003). Introduction to evolutionary computing. Berlin, Heidelberg: Springer. Talbi, E.-G. (2009). Metaheuristics: From design to implementation. Hoboken, NJ: John Wiley & Sons. Yang, X.-S. (2020). Elements of nature-inspired optimization. Boca Raton, FL: CRC Press.

1	**Code of the subject**	CS306
2	**Title of the subject**	Machine Learning
3	**Prerequisite**	Linear Algebra
4	**L-T-P**	3-0-2
5	**Learning Objectives**	To understand popular ML algorithms with their associated mathematical foundations and use them for solving real world problems as machine learning tasks
6	**Brief Contents**	Introduction and Fundamentals of ML. Selected Algorithms - Ensembling and RF, Linear SVM, K Means,Logistic Regression, Naive Bayes etc. Neural Network Learning - Role of Loss Functions and Optimization, Gradient Descent and Perceptron/Delta Learning, MLP, Backpropagation, MLP for Classification and Regression, Regularisation, Early Stopping. Kernels (with SVM), Bayesian Methods, Generative Methods, HMM, EM, PAC learning. Introduction to Deep Learning, CNNs, Popular CNN Architectures, RNNs, GANS and Generative Models, Advances in Backpropagation and Optimization for Neural Networks Adversarial Learning
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**Text /references**	1. Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, Mathematics for Machine Learning, Cambridge University Press 2. Tom M. Mitchell, Machine Learning - McGraw Hill Education, International Edition 3. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, O'Reilly Media, Inc. 2nd Edition 4. Ian Goodfellow, Yoshoua Bengio, and Aaron Courville, Deep Learning MIT Press Ltd, Illustrated edition 5. Christopher M. Bishop, Pattern Recognition and Machine Learning - Springer, 2nd edition 6. Trevor Hastie, Robert Tibshirani, and Jerome Friedman, The Elements of Statistical Learning: Data Mining, Inference, and Prediction - Springer, 2nd edition

1	**Code of the subject**	CS307
2	**Title of the subject**	Information Security Systems
3	**Prerequisite**	No
4	**L-T-P**	3-0-2
5	**Learning Objectives**	This course provides a comprehensive study of the security principles and practices of information systems. Helps build a good understanding of the foundational theory behind computer security and the threats.
6	**Brief Contents**	Security issues in computing, communications, and electronic commerce. Goals and vulnerabilities; legal and ethical issues; basic cryptology; private and authenticated communication; electronic commerce; software security; viruses and other

		malicious code; operating system protection; trusted systems design; network security; firewalls; policy, administration and procedures; auditing; physical security; disaster recovery; reliability; content protection; privacy.
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**Text /references**	1. William Stallings and Lawrie Brown. 2014. Computer Security: Principles and Practice (3rd ed.). Prentice Hall Press, Upper Saddle River, NJ, USA. 2. Behrouz A. Forouzan. 2007. Cryptography & Network Security 3. M. Stamp, Information Security: Principles and Practice, Wiley 4. M. E. Whitman and H. J. Mattord, Principles of Information Security.

1	**Code of the subject**	CS401
2	**Title of the subject**	Natural Language Processing
3	**Prerequisite**	AI and ML
4	**L-T-P**	3-0-2
5	**Learning Objectives**	To equip the learners with fundamental and advanced aspects of NLP applications.
6	**Brief Contents**	Human language processing paradigms; Phases in natural language processing, applications. Text representation in computers, encoding schemes. Introduction to corpus, elements in balanced corpus, TreeBank, PropBank, WordNet, VerbNet etc. Resource management with XML, Management of linguistic data with the help of GATE, NLTK. Regular expressions, Finite State Automata, word recognition, lexicon. Morphology, acquisition models, Finite State Transducer. N-grams, smoothing, entropy, HMM, ME, SVM, CRF. Speech tagging. Review of natural language grammars, lexeme, phonemes, phrases and idioms, word order, agreement, tense, aspect and mood and agreement, Context Free Grammar, spoken language syntax. Parsing, Word Sense Disambiguation, Discourse- Reference resolution etc. Applications of NLP, Summarization Information, Machine Translation overview.
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**Text /references**	1. Daniel Jurafsky and James H Martin, Speech and Language Processing: An introduction to Natural Language Processing, Computational Linguistics and Speech Recognition, Prentice Hall, 2nd Edition, 2008.

1	**Code of the subject**	CS402
2	**Title of the subject**	Digital Image Processing
3	**Prerequisite**	Mathematics
4	**L-T-P**	3-0-2
5	**Learning Objectives**	To introduce the basic concepts of Digital image processing with emphasis on applications in various field of recent research.
6	**Brief Contents**	Introduction and Fundamentals, Image Enhancement in Spatial Domain, Image Enhancement in Frequency Domain, Image Restoration, Segmentation, Representation and Description.
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**Text /references**	1.Digital Image Processing 2nd Edition, Rafael C. Gonzalvez and Richard E. Woods. Published by: Pearson Education. 2.R.J. Schalkoff ,Digital Image Processing and Computer Vision John Wiley and Sons, NY. 3. William K. Prat, Digital Image Processing, John Wiley and Sons, NY

1	**Code of the subject**	CS403
2	**Title of the subject**	Cloud Computing
3	**Any prerequisite**	Computer Networks, OS, Software engineering, Distributed Computing
4	**L-T-P**	3-0-0
5	**Learning Objectives**	To equip with the enabling technology for an on-demand access to a shared pool of configurable computing resources. To introduce various aspects of cloud computing paradigm and future research trends.
6	**Brief Contents**	Introduction to Cloud Computing, Introduction to Parallel and Distributed Computing, Cloud Computing Architecture, Service Management, Data Management in Cloud Computing, Virtualization & Resource Management, Cloud Security, Open Source and Commercial Clouds, Cloud Simulator, Research trend in Cloud Computing, Fog Computing.
8	**Text /references**	1. Cloud Computing: Principles and Paradigms, Editors: RajkumarBuyya, James Broberg, Andrzej M. Goscinski, Wiley 2. Enterprise Cloud Computing - Technology, Architecture, Applications, Gautam Shroff, Cambridge University Press 3. Cloud Computing Bible, Barrie Sosinsky, Wiley-India 4. Cloud Security: A Comprehensive Guide to Secure Cloud Computing, Ronald L. Krutz, Russell Dean Vines, Wiley

1	**Code of the subject**	CS404
2	**Title of the subject**	Big Data Analytics

3	**Prerequisite**	No
4	**L-T-P**	3-0-0
5	**Learning Objectives**	Understanding of core concepts behind big data problems, applications, systems and the techniques along with an introduction to some of the most common Big Data frameworks and Big Data Streaming Platforms.
6	**Brief Contents**	Introduction to Big Data, Enabling Technologies for Big Data, Big Data Stack, Big Data distribution packages. Big Data Platforms, Overview of Apache Spark, HDFS, YARN, Introduction to MapReduce, MapReduce Programming Model with Spark, MapReduce Example: Word Count, Page Rank etc. Introduction to Big Data Storage Platforms for Large Scale Data Storage, CAP Theorem, Eventual Consistency, ACID and BASE, Zookeeper and Paxos, Cassandra, HBase Big Data Streaming Platforms for Fast Data, Big Data Streaming Systems, Big Data Pipelines for Real-Time computing, Spark Streaming, Kafka, Streaming Ecosystem. Introduction to Big Data Applications (Machine Learning), Overview of Big Data Machine Learning, Mahout, Big Data Machine Learning Algorithms in Mahout- kmeans, Naïve Bayes etc. Introduction of Big Data Machine learning with Spark, Big Data Machine Learning Algorithms in Spark- Introduction to Spark MLlib, Introduction to Deep Learning for Big Data. Introduction to Big Data Applications (Graph Processing), Introduction to Pregel, Introduction to Giraph, Introduction to Spark GraphX.
8	**Text /references**	1. Big Data Science & Analytics: A Hands-On Approach, Arshdeep Bahga and Vijay Madisetti, VPT. 2. The Big Data Tidal Wave: Finding Opportunities in Huge Data Streams with Advanced Analytics, Bill Franks, Wiley. 3. Big Data Analytics: Disruptive Technologies for Changing the Game, ArvindSathi, MC Press. 4. Hadoop: The Definitive Guide, Tom White, O'Reilly.

1	**Code of the subject**	CS498
2	**Title of the subject**	Colloquium (Based on industrial training)/ MOOC
3	**Prerequisite**	
4	**L-T-P**	0-0-6
5	**Learning Objectives of the subject**	To instill the ability to identify skills and gain practical work experience To provide an opportunity to observe and contribute in the workplace To take ownership and responsibility of a project assignment, given by a designated manager/supervisor

		To provide networking opportunities with other members of the organization To offer performance feedback and mentorship throughout the internship
6	**Brief Contents**	An internship helps you train under experienced professionals and explore what your chosen career path would be like, and an internship with a company in your field can help you to develop the skills you require to thrive within a professional setting. At the end of the training period, the company may ask you to review your time with them and write a report based on your experience. In addition, hone the skills needed to develop internship report.
7	**Contents for lab**	There are no specific laboratory sessions for this. However, this being a completely practical oriented course, the student has to devote significant time to achieve the objectives.
8	**Text /references**	1. https://www.careereducation.columbia.edu/resources/10-tips-make-most-internship 2. https://in.indeed.com/career-advice/career-development/internship-report

1	**Code of the subject**	CS499
2	**Title of the subject**	BTech Project/ Internship
3	**Any prerequisite**	
4	**L-T-P**	0-0-24
5	**Learning Objectives**	To develop deeper knowledge, understanding, capabilities and attitudes in the context of the programme of study.
6	**Brief Contents**	The purpose of this course is to enable the student to develop deeper knowledge, understanding, capabilities and attitudes in the context of the programme of study. The student is expected to demonstrate the abilities of the major subject/field of study, including deeper insight into hardware/software application development work. Develop the capability to create, analyse and critically evaluate different technical/architectural solutions. Equip with the needed skills to clearly present and discuss theconclusions as well as the knowledge and arguments that form the basis for the learning outcome in written and spoken English. Importantly it is necessary to march on the ethical aspects of research and development work.
7	**Contents for lab**	There are no specific laboratory sessions for this. However, this being a completely practical oriented course, the student has to devote significant time to achieve the objectives.
8	**List of text books/references**	https://grad.wisc.edu/wp-content/uploads/sites/329/2018/02/2018-Project-Management-for-Graduate-Students-Course-Workbook.pdf

1	**Code of the subject**	CS001
2	**Title of the subject**	Graph Theory
3	**Any prerequisite**	Nil
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	• Understanding the basic graph theory concepts • Knowledge of the use of graph theory in various problem domains.
6	**Brief Contents**	Introduction to Graphs: Definition of a graph, graphs as models, finite and infinite graphs, matrix representation of graphs, incidence and adjacency matrices of graphs, graph isomorphisms, types of graphs, subgraphs, walks, trails, paths, cycles, connectivity, components of a graph, bipartite graphs, vertex degrees and counting, graphic sequences. Trees and Distance: Definition and properties of trees, rooted and binary trees, spanning trees, counting trees and spanning trees, weighted graphs, minimum spanning tree, Kruskal's Algorithm, Prim's algorithm, Dijkstra's algorithm, shortest paths. Euler and Hamiltonian graphs: Euler tours, Fleury's algorithm, Hamiltonian cycles, Dirac's theorem, closure of a graph, Bondy and Chvatal theorem, the travelling salesman problem, algorithm to find smaller Hamiltonian cycle in complete graphs. Planar Graphs: Planar graphs, detection of planarity, Euler's formula for planar graphs, the platonic bodies, Kuratowski's theorem. Coloring of Graphs: Vertex coloring and upper bounds, chromatic number, Greedy algorithm, Brook's theorem, counting proper colorings, chromatic polynomial. Directed Graphs: Types of digraphs, directed paths and connectedness, Euler digraphs
8	**List of text books/references**	1. D. B. West, Introduction to Graph Theory, Prentice Hall India, 2nd Ed. 2009 2. Clark and D. A. Holton, A First Look at Graph Theory, Allied Publ. 1995 3. N. Deo, Graph Theory with Applications to Engineering and Computer Science, Dover Publications. 2016 4. J. A. Bondy and U. S. R. Murty, Graph Theory, Springer 2011 5. G. Chartrand and P. Zhang, Introduction to Graph Theory, Tata McGraw Hill. 2007

		6. R. J. Wilson, Introduction to Graph Theory, Pearson Education, eBook. 2015

1	**Code of the subject**	CS002
2	**Title of the subject**	Software, System Analysis and Design
3	**Any prerequisite**	No
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	1. Outline the software design process, and demonstrate how the essential design principles are applied within it. 2. Illustrate the essential elements of software structure and architecture in terms of styles, patterns and families of programs and frameworks. 3. Demonstrate the application of quality analysis and evaluation principles. 4. Employ function, object, data-structure and component-based design methodologies in a typical software design project.
6	**Brief Contents**	1. Software Design Fundamentals: General design concepts, Context of software design, Software design process, Software design principles. 2. Key Issues in Software Design: Concurrency, Control and handling of events, Data persistence, Distribution of components, Error exception handling and fault tolerance, Interaction and presentation, Security. 3. Software Structure and Architecture: Architectural structures and viewpoints, Architectural styles, Design patterns, Architecture design decisions, Families of programs and frameworks 4. User Interface Design: General user interface design principles, User interface design issues, Design of user interaction modalities, Design of information presentation, User interface design process, Localization and internationalization, Metaphors and conceptual models 5. Software Design Quality Analysis and Evaluation: Quality attributes, Quality analysis and evaluation techniques, Measures. 6. Software Design Notations: Structural descriptions (static view), Behavioral descriptions (dynamic view). 7. Software Design Strategies and Methods: General strategies, Function-oriented (structured) design, Object-oriented design, Data structure-oriented design, Component-based design, other methods.
7	**Contents for lab**	Assignments

8	**List of text books/references**	1. Systems Analysis and Design (MindTap Course List) 12th Edition by Scott Tilley, 2019. 2. Head First Design Patterns: Building Extensible and Maintainable Object-Oriented Software 2nd Edition 2nd Edition by Eric Freema. 3. Designing Data-Intensive Applications: The Big Ideas Behind Reliable, Scalable, and Maintainable Systems Kindle Edition by Martin Kleppmann.

1	**Code of the subject**	CS003
2	**Title of the subject**	Digital Signal Processing
3	**Prerequisite**	
4	**L-T-P**	3-0-0
5	**Learning Objectives**	In this course, we will mainly study the following topics: signal representation in time domain, Fourier transform, sampling theorem, linear time-invariant system, discrete convolution, z-transform, discrete Fourier transform, and discrete filter design.After this course, the students should be able to understand how to analyse a given signal or system using tools such as Fourier transform and z-transform; how to process signals to make them more useful.
6	**Brief Contents**	Review of Signals and Systems: Discrete time complex exponentials and other basic signals-scaling of the independent axis and differences from its continuous-time counterpart-system properties (linearity, time-invariance, memory, causality, BIBO stability)-LTI systems, convolution, correlation, continuous-time Fourier series and Fourier transform. Sampling: Impulse train sampling and reconstruction, aliasing, A/D and D/A conversion, quantization noise. Discrete-Time Fourier Transform (DTFT): Complex exponentials as Eigen signals of LTI systems-DTFT definition-inversion formula-properties-relationship to continuous-time Fourier series (CTFS). Z-Transform: Generalized complex exponentials as eigensignals of LTI systems-z-transform definition-region of convergence (RoC)-properties of RoC-properties of the z-transform, inverse z-transform methods,pole-zero plots, RoC implications of causality and stability. Frequency Domain Analysis of LTI Systems: Frequency response of systems with rational transfer function, definitions of magnitude and phase response, geometric method of frequency response evaluation from pole-zero plot, frequency response of single complex zero/pole, frequency response of filters. Discrete Fourier Transform (DFT): Definition of the DFT and inverse DFT-circular shift of signal and the ―index mod N‖ concept-properties of the DFT-circular convolution and its relationship with linear convolution—sectioned convolution methods: overlap add and overlap save-effect of zero padding.
7	**Contents for lab**	

8	**Text /references**	1. Discrete-Time Signal Processing by Alan V. Oppenheim and Ronald W. Schafer, 3rd edition, 2010, Prentice Hall, Upper Saddle River, NJ. 2. Digital Signal Processing by SanjitMitra, 4th edition, 2011, McGraw-Hill, New York, NY.

1	**Code of the subject**	CS005
2	**Title of the subject**	Cryptography and Network Security
3	**Prerequisite**	
4	**L-T-P**	3-0-0
5	**Learning Objectives**	To develop a framework to understand and implement cryptographic aspects. To enhance an ability to analyze a problem, and identify and define the computing requirements for data security. To prepare abstract and critical thinking background for computer science students
6	**Brief Contents**	Module I- Introduction Classical Encryption Techniques: Symmetric Cipher Model, Substitution Techniques, Transposition Techniques, Stream Cipher and Block Cipher, Random Number Generator, One-time Pad. Module II- Finite Field and Number Theory Groups, Rings, Fields, Modular Arithmetic, Euclid‘s Algorithm, Finite Fields Of Form GF (p) And GF (2n). Polynomial Arithmetic, Prime Numbers, Fermat‘s And Euler‘s Theorem, Testing For Primality, The Chinese Remainder Theorem, Discrete Logarithms. Module III-Symmetric Cipher and Public Key Encryption Block Cipher Principles, Data Encryption Standard (DES), Multiple Encryption, Triple DES, Advanced Encryption Standard (AES), Principles of Public Key Cryptosystems, The RSA Algorithm, Key Management, Elliptic Curve Arithmetic, Elliptic Curve Cryptography. Module IV-Cryptographic Protocols Authentication Requirement, Authentication Function, MAC, Hash Functions, Security of Hash Function , Digital Signatures, Module V-Network Security and Applications Authentication applications: Kerberos – X.509 Authentication services, Public Key Infrastructure, Pretty Good Privacy, S/MIME IP security: Encapsulating Security Payload (ESP)-Internet Key Exchange (Phases of IKE, ISAKMP/IKE Encoding) Web Security: Web Security Considerations, Secure Socket Layer and Transport layer Security, System Security
7	**Contents for lab**	
8	**List of text books/references**	1. William Stallings, Cryptography and Network security, 4e,Prentice Hall of India, New Jersey, 2008. 2. ChristofPaar, Jan Pelzl, Understanding Cryptography, Springer-Verlang, Berlin, 2010

		3. Behrouz A Forouzan, Cryptography and Network security, Tata Mc-Graw Hill, New York, 2007.

1	**Code of the subject**	CS006
2	**Title of the subject**	Control System Engineering
3	**Prerequisite**	
4	**L-T-P**	3-0-0
5	**Learning Objectives**	To be able to obtain a working mathematical model of a system. To be able to do time-domain and frequency-domain analyses of the model to predict the system's behaviour. To be able to design control systems that meet design specifications.
6	**Brief Contents**	Introduction, Mathematical modelling, Time response of dynamical systems, Stability, feedback control, Design of controllers, Frequency domain analysis, design of compensators
7	**Contents for lab**	
8	**Text books/references**	1. G.F. Franklin, J. D. Powell, A. Emami-Naeini, "Feedback Control of Dynamic Systems", Pearson, Upper Saddle River, New Jersey, 5th edition, 2006. 2. K. Ogata, "Modern Control Engineering", Prentice-Hall of India Pvt Ltd., New Delhi, 3rd edition, 2000. 3. B. C. Kuo, "Automatic Control Systems", Prentice-Hall of India Pvt Ltd., New Delhi, 6th, edition, 1991. 4. Nagrath & Gopal, Control Systems

1	**Code of the subject**	CS007
2	**Title of the subject**	System Simulation and Modeling
3	**Prerequisite**	
4	**L-T-P**	3-0-0
5	**Learning Objectives**	Introduce computer simulation technologies and techniques, provide the foundations for the student to understand computer simulation needs, and to implement and test a variety of simulation and data analysis libraries and programs To introduce concepts of modeling layers of society's critical infrastructure networks and to build tools to view and control simulations and their results.
6	**Brief Contents**	Module – 1 Simulation Basics : Handling Stepped and Event-based Time in Simulations, Discrete versus Continuous Modelling, Numerical Techniques, Sources and Propagation of Error Module – 2 Dynamical, Finite State, and Complex Model Simulations: Graph or Network Transitions Based Simulations, Actor Based Simulations, Mesh Based Simulations, Hybrid Simulations

		Module – 3 Converting to Parallel and Distributed Simulations : Partitioning the Data, Partitioning the Algorithms, Handling Inter-partition Dependencies Module – 4 Probability and Statisics for Simulations and Analysis : Review of terminology, concepts, Useful statistical models, Discrete Distributions ,Continuous Distributions, Poisson Process, Empirical distributions, Introduction to Queues and Random Noise, Random Variates Generation, Sensitivity Analysis, The basics of SpreadSheet-Simulation, Simulation Example: Simulation of queuing systems in a spreadsheet Module 5- Random-Number Generation, Random-Variate Generation : Properties of random numbers, Generation of pseudo-random numbers ,Techniques for generating random numbers ,Tests for Random Numbers, Random- Variate Generation ,Inverse transform technique ,Acceptance-Rejection technique, Special properties Module 6 -Input Modeling: Data Collection, Identifying the distribution with data, Parameter Estimation, Goodness of Fit Tests, Fitting a non-stationary Poisson process ,Selecting input models without data , Multi-variate and Time-Series input models Module 7- Queuing Models: Characteristics of queuing Systems, Queuing notation , Long-run measures of performance of queuing Systems, Steady-state behavior of M/G/1 queue, Networks of queues ,Rough-cut modeling: An illustration. Module – 8 Simulations Results Analysis and Viewing Tools : Display Forms: Tables, Graphs, and Multidimensional Visualization, Terminals, X and MS Windows, and Web Interfaces, Validation of Model Results.
7	**Contents for lab**	
8	**Text books/references**	1. Jerry Banks, John S. Carson II, Barry L. Nelson, David M. Nicol: Discrete-Event System Simulation. (Listed topics only from Chapters-1 to 12), 5th Edition, Pearson Education ©2013 2. Averill M. Law: Simulation Modeling and Analysis , 4th Edition, Tata McGraw-Hill, 2007.ISBN : 9780070667334 3. Lawrence M. Leemis, Stephen K. Park: Discrete – Event Simulation: A First Course,Pearson Education, 2006.ISBN: 978-0131429178

1	**Code of the subject**	CS008
2	**Title of the subject**	IoT Protocols
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	To introduce the terminology, technology and its applications To introduce the concept of M2M (machine to machine) with necessary protocols To introduce the Python Scripting Language which is used in many IoT devices

		To introduce the Raspberry PI platform, that is widely used in IoT applications To introduce the implementation of web-based services on IoT devices
6	**Brief Contents**	Module 1: Introduction to Signals and systems, Introduction to Internet of Things, Physical Design of IoT – IoT Protocols, IoT communication models, IoT Communication APIs, IoT enabled Technologies – Wireless Sensor Networks, Cloud Computing, Embedded Systems, IoT Levels and Templates, Domain Specific IoTs – Home, City, Environment, Energy, Agriculture and Industry. Module 2: IoT and M2M- Software defined networks, network function virtualization, difference between SDN and NFV for IoT, Basics of IoT System Management with NETCONF, YANG- NETCONF, YANG, SNMP NETOPEER Module 3: IoT Physical Devices and Endpoints- Introduction to Arduino and Raspberry Pi- Installation, Interfaces (serial, SPI, I2C) Controlling Hardware- Connecting LED, Buzzer, Switching High Power devices with transistors, Controlling AC Power devices with Relays, Controlling servo motor, speed control of DC Motor, unipolar and bipolar Stepper motors Module 4: Sensors- Light sensor, temperature sensor with thermistor, voltage sensor, ADC and DAC, Temperature and Humidity Sensor DHT11, Motion Detection Sensors, Wireless Bluetooth Sensors, Level Sensors, USB Sensors, Embedded Sensors, Distance Measurement with ultrasoundsensor Module 5: IoT Physical Servers and Cloud Offerings– Introduction to Cloud Storage models and communication APIs Web Server – Web server for IoT, Cloud for IoT, Python web application framework Designing a RESTful web API
7	**Contents for lab**	
8	**List of text books/references**	1. Internet of Things - A Hands-on Approach, Arshdeep Bahga and Vijay Madisetti, Universities Press, 2015, ISBN: 9788173719547 2. Getting Started with Raspberry Pi, Matt Richardson & Shawn Wallace, O'Reilly (SPD), 2014, ISBN: 9789350239759 3. Raspberry Pi Cookbook, Software and Hardware Problems and solutions, Simon Monk, O'Reilly (SPD), 2016, ISBN 7989352133895

1	**Code of the subject**	CS009
2	**Title of the subject**	Game Programming
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	This course provides an introduction to game engine scripting, event driven and data driven programming, game engine data structures, basic game related graphics and AI concepts.

6	**Brief Contents**	Module 1: Introduction to Game Programming and Unity, The Game Loop, Scene Modeling Module 2: Introduction to Animation, Keyframing, Character Animation and Rigging, Animation Controllers, Game UIs Module 3: Kinematics, Particle Effects, Physics-based Animation, Numerical Integration, Rigid Body Simulation, Collisions, Sound, Procedural Content Generation Module 4: Game AI: Planning, Pathfinding, Decision Making Module 5: Game Networking, Game Business and Ethics
7	**Contents for lab**	
8	**List of text books/references**	1. Mike Mc Shaffrfy and David Graham, "Game Coding Complete", Fourth Edition, Cengage Learning, PTR, 2012. 2. Jason Gregory, "Game Engine Architecture", CRC Press / A K Peters, 2009. 3. David H. Eberly, "3D Game Engine Design, Second Edition: A Practical Approach to Real-Time Computer Graphics" 2nd Editions, Morgan Kaufmann, 2006. 4. Ernest Adams and Andrew Rollings, "Fundamentals of Game Design", 2nd Edition Prentice Hall / New Riders, 2009. 5. Eric Lengyel, "Mathematics for 3D Game Programming and Computer Graphics", 3rd Edition, Course Technology PTR, 2011. 6. Jesse Schell, The Art of Game Design: A book of lenses, 1st Edition, CRC Press, 2008.

1	**Code of the subject**	CS010
2	**Title of the subject**	Formal Languages and Automata
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	To discuss key notions of computation, such as algorithm, computability, decidability, reducibility, and complexity, through problem solving. To explain the models of computation, including formal languages, grammars and automata, and their connections. state and explain the Church-Turing thesis and its significance. To analyze and design finite automata, pushdown automata, Turing machines, formal languages, and grammars. To solve computational problems regarding their computability and complexity and prove the basic results of the theory of computation.
6	**Brief Contents**	Module I:Automata and Languages - finite automata and regular expressions, pushdown automata and context-free grammars, pumping lemmas and closure proprties of regular and context-free languages, non-context-free languages Module II:Computability theory - the Church-Turing thesis, Hilbert's problem, decidability, halting problem, reducibility Module III:Complexity theory - time and space complexity, Classes P, NP, NP-complete, PSPACE, and PSPACE-complete

		Module IV:Intractability - hierarchy theorem, Relativization, Circuit complexity Module V: Computable Functions- Primitive Recursive Functions, PRF and Bounded Operations, Unbounded. Minimalization and ų-Recursive Functions, Godel Numbering
7	**Contents for lab**	
8	**List of text books/references**	1. M. Sipser, Introduction to the Theory of Computation, Thomson, 2004. 2. H. R. Lewis and C. H. Papadimitriou, Elements of the Theory of Computation, PHI, 1981. 3. J. L. Balcazar, J. Diaz and J. Gabarro, Structural Complexity, Vols 1 & 2, EATCS Monographs, Springer-Verlag, 1987. 4. John Martin. (2010). Introduction to languages and the theory of computation, (4th ed.). New York: McGraw-Hill Science/Engineering/Math. 5. Tourlakis, George J. (2012). Theory of computation. Hoboken: Wiley.

1	**Code of the subject**	CS011
2	**Title of the subject**	Advanced Network Technologies
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Learning Objectives**	To understand the interconnection for high performance computing, protocols and techniques used for enhancing data delivery ratio, ensuring QoS. Wireless sensor networks and protocols to support cyber physical system interaction and components of IoT.
6	**Brief Contents**	Module 1: Gigabit Networking High Performance Computing and Communications Program (HPCC) basics, Broadband networks, Gigabit testbeds worldwide, Network switching technologies: architecture and performance parameters, Gigabit network design preliminaries. Module 2: Wireless Sensor Networks Sensor network architecture, Design principles, Optimization goals and figures of merit, Communication protocols, Link layer protocols, Localization and positioning, Topology control, Routing protocols, Advanced application support. Module 3: Content Delivery Networks Early Days of Content Delivery over the Internet World Wide Web—Where It Came From and What It Is Evolution of Content Networking Diversity of Interests in Content Networking; Content Transport: Protocol Architecture and Design Paradigms of the Internet, Hypertext Transport Protocol—HTTP, Multicast Transport; Caching Techniques for Web Content; Caching Techniques for Streaming Media.
7	**Contents for lab**	

8	**List of text books/references**	1. Gigabit Networking‖ (Addison-Wesley Professional Computing Series), Craig Partridge, Addison Wesley, 1994. 2. Protocol and Architectures for Wireless Sensor Networks‖, Holger Karl, Andreas Willig, Wiley, 2005. 3. Content Networking Architecture, Protocols, and Practice‖, M. Hofmann, L. R. Beaumont, .Morgan Kaufmann, 2005.

1	**Code of the subject**	CS012
2	**Title of the subject**	Empirical Techniques in Software Engineering
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Learning Objectives**	1. Design empirical studies for different purposes (e.g., evaluating a tool, understanding a phenomenon); choose appropriate methods and defend the choice. 2. Collect and analyze qualitative and quantitative data 3. Mine data from online repositories. 4. Run statistical tests and interpret results. 5. Draw conclusions from empirical data.
6	**Brief Contents**	What Is Empirical Software Engineering? Overview of Empirical Studies, Types of Empirical Studies, Empirical Study Process, Basic Elements of Empirical Research Software Metrics: Measurement Basics, OO metrics, dynamic metrics, System Evolution and Evolutionary Metrics, validation of software metrics. Experimental design: Overview of Experimental Design, Research Questions, Research Variables, Hypothesis Formulation, Data Collection, selection of Data analysis methods. Mining Data from Software Repositories: Configuration Management Systems, Importance of Mining Software Repositories, version control system, bug tracking systems, static source code analysis, software historical analysis. Data Analysis and Statistical Testing, Model Development and Interpretation, Validity Threats, Categories of Threats to Validity.
7	**Contents for lab**	
8	**List of text books/references**	1. Empirical Research in Software Engineering Concepts, Analysis, and Applications By Ruchika Malhotra. 2. Clases Wohlin, Per Runeson, Martin Host, Magnus C. Ohlsson, Bjorn Regnell, Anders Wesslen Experimentation in Software Engineering: An Introduction November 1999, Kluwer Academic Pub. 3. Tonella P., Torchiano, M., Du Bois, B., Systa, T. 2007. Empirical studies in reverse engineering: state of the art and future trends. In Empirical Software Engineering, Vol. 12(5), Springer, 551-571

1	**Code of the subject**	CS013
2	**Title of the subject**	Digital Water Marking and Steganalysis

3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Learning Objectives**	The objective of the course makes students familiar about Digital watermarking and steganography.
6	**Brief Contents**	Module I-Introduction: Information Hiding, Steganography, and Watermarking, Importance of Digital Watermarking, Steganography Applications and Properties: Applications of Watermarking, Applications of Steganography, Properties of Watermarking Systems, Evaluating Watermarking Systems, Properties of Steganographic and Steganalysis Systems, Evaluating and Testing Steganographic Systems Module II-Models of Watermarking: Communication-Based Models of Watermarking, Geometric Models of Watermarking, Modeling Watermark Detection by Correlation, Basic Message Coding: Mapping Messages into Message Vectors, Error Correction Coding, Detecting Multi-symbol Watermarks Module III- Watermarking with Side Information: Informed Embedding, Watermarking Using Side Information, Dirty-Paper Codes Robust Watermarking: Approaches, Robustness to Volumetric Distortions, Robustness to Temporal and Geometric Distortions Module IV- Watermark Security: Security Requirements, Watermark Security and Cryptography, Some Significant Known Attacks Content Authentication: Exact Authentication, Selective Authentication, Localization, Restoration, Steganography: Notation and Terminology, Information-Theoretic Foundations of Steganography, Practical Steganographic Methods, Minimizing the Embedding Impact Steganalysis: Steganalysis Scenarios, Some Significant Steganalysis Algorithms.
7	**Contents for lab**	
8	**List of text books/references**	1. Digital Watermarking and Steganography, Ingemar J. Cox, Matthew L. Miller, Jeffrey A. Bloom, Jessica Fridrich, Ton Kalker, Morgan Kauffman 2. Digital Watermarking principles, Ingemar J. Cox, Matthew L. Miller, Jeffrey A. Bloom, Morgan Kauffman

1	**Code of the subject**	CS014
2	**Title of the subject**	Deep Learning
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Learning Objectives**	1. Introduce deep learning algorithms, the problem settings, and their applications to solve real world problems. 2. Provide an understanding of the theoretical basis underlying neural networks and deep learning.

6	**Brief Contents**	Module 1: History of Deep Learning, Deep Learning Success Stories, McCulloch Pitts Neuron, Thresholding Logic, Perceptron, Perceptron Learning Algorithm. Module 2: Multilayer Perceptron (MLPs), Representation Power of MLPs, Sigmoid Neurons, Feedforward Neural Networks, Representation Power of Feedforward Neural Networks Module 3: Gradient Descent (GD), Momentum Based GD, Nesterov Accelerated GD, Stochastic GD, AdaGrad, RMSProp, Adam, Eigenvalues and eigenvectors, Eigenvalue Decomposition, Basis. Module 4: Principal Component Analysis and its interpretations, Singular Value Decomposition Module 5: Autoencoders and relation to PCA, Regularization in autoencoders, Denoising autoencoders, Sparse autoencoders, Contractive autoencoders Module 6: Regularization: Bias Variance Tradeoff, L2 regularization, Early stopping, Dataset augmentation, Parameter sharing and tying, Injecting noise at input, Ensemble methods, Dropout. Module 7: Greedy Layer-wise Pre-training, Better activation functions, Better weight initialization methods, Batch Normalization Module 8: Convolutional Neural Networks, AlexNet, ZF-Net, VGGNet, GoogleNet, ResNet, Visualizing Convolutional Neural Networks, Guided Backpropagation, Deep Dream, Deep Art, Fooling Convolutional Neural Networks Module 9: Recurrent Neural Networks, Backpropagation through time (BPTT), Vanishing and Exploding Gradients, Truncated BPTT, GRU, LSTMs Module 10: Encoder Decoder Models, Attention Mechanism, Attention over images.
7	**Contents for lab**	Exploration and implementation of deep-learning models using Tensor Flow, PyTorch and Caffe.
8	**List of text books/references**	1. Ian Goodfelllow, Yoshua Benjio, Aaron Courville, “Deep Learning”, The MIT Press, 2016. 2. Richard O. Duda, Peter E. Hart, David G. Stork, “Pattern Classification”, John Wiley & Sons Inc. 3. Research Papers.

1	**Code of the subject**	CS015
2	**Title of the subject**	Blockchain Technology
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Learning Objectives**	• Get an overview of blockchain technology, its history, benefits, drawbacks, and future. • Examine the nascent blockchain technology and make an initial pass at identifying some of its major vulnerabilities. • Design, build, and deploy distributed applications

		• Shall equip students with the skills necessary to create e-governance applications for the public good.
6	**Brief Contents**	Module I: Introduction: Overview of Blockchain, Public Ledgers, Bitcoin, Smart Contracts, Block in a Block chain, Transactions, Distributed Consensus, Types of consensus algorithms, Types of Block chain -Public vs Private Block chain, Understanding Crypto currency, A basic crypto currency Module II: Overview of Security aspects of Block chain. Basic Crypto Primitives: Cryptographic Hash Function, Properties of a hash function, Hash pointer and Merkle tree, Symmetric key cryptography, Asymmetric key cryptography, Public Key cryptography, Digital Signature. Module III: Byzantine General problem and Fault Tolerance, Mining Mechanism, Energy usage, Distributed Consensus, Merkle Tree, Transactions and Fee, Anonymity, Reward, Bitcoin Transaction structure, Double Spending Problem, Privacy in blockchains. Module IV: Introduction to Consensus Problem, Distributed Consensus, Nakamoto consensus, Proof of Work (PoW), Proof of Stake (PoS), Delegated Proof of Stake (DPoS), Leased Proof of Stake (LPoS), Proof of Elapsed Time (PEoT), Tangle, Proof of Burn (PoB), Difficulty Level, Energy utilization and alternate, Consensus in Etherium. Module V: Application of DLT in e-governance, Banking and Finance, Virtual Machine- Swarm and IPFS- Installing IPFS, IPFS file uploader, Understanding blockchain for Enterprises – Project (Eg. Enterprise application of blockchain, Food security, Blockchain enabled Trade, finance network, Supply chain, and Identity on blockchain.)
7	**Contents for lab**	
8	**List of text books/references**	1. Michael E. Whitman and Herbert J. Mattord: Principles of Information Security, 2nd Edition, Cengage Learning, 2005. (Chapters 5, 6, 7, 8; Exclude the topics not mentioned in the syllabus). 2. Behrouz A. Forouzan and Debdeep Mukhopadhyay: Cryptography and Network Security, 2nd Edition Tata McGraw Hill, 2010. (Chapters: 1, 3, 6, 7, 10, 11, 15, 16, 17, 18).

1	**Code of the subject**	CS016
2	**Title of the subject**	Introduction to Robotics
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Learning Objectives**	The course work will be helpful for the students to understand the basic principles of robotics. They will learn about the components, modelling and basic operations of the robots.

6	**Brief Contents**	SystemsOverview of a Robot, Mechanical Systems, Components, Dynamics and Modeling, Control of Actuators in Robotic Mechanisms, Robotic Sensory Devices. PerformanceDefinition - Accuracy/ Repeatability/ Precision with respect to Position &Path, payload, speed, acceleration, cycle time Challenges/plicationsandusesofMobileandotherrobots: wheeled, tracked, legged, aerial, underwater robots, surgical robots, rehabilitation robots, humanoidrobots Introduction to robot manipulation. Forward and inverse kinematics of robots and some case studies. Manipulator dynamics. Basics of robot control. Taskplanningwith emphasis on computational geometry methods for robot path finding, robot arm reachability, grasp planning etc. Overview of robot vision.
7	**Contents for lab**	
8	**List of text books/references**	1. Richard D. Klafter, Robotic Engineering: An Integrated Approach, Phi 2. R. J. Schilling, Fundamentals of Robotics: Analysis And Control, Prentice-Hall India References: 1. Francis N. Nagy, Andrassiegler, Engineering Foundation of Robotics, Prentice Hall Inc 2. P.A. Janaki Raman, Robotics And Image Processing An Introduction, Tata Mc Graw Hill Publishing Company Ltd. 3. Mikell P. Grooyer, Mitchell Weiss, Roger N. Nagel, Nicholas G. Odrey, Industrial Robotics, Technology Programming And Applications, Mc Graw Hill International Edition 4. S.R. Deb, Robotics Technology And Flexible Automation, Tata Mc Graw Hill Publishing Company Ltd. 5. Carl D. Crane And Joseph Duffy, Kinematic Analysis Of Robot Manipulation, Cambridge University Press

1	**Code of the subject**	CS017
2	**Title of the subject**	Stochastic Processes and Queuing Theory
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Learning Objectives**	Many complex systems are modeled using stochastic processes. This course will introduce students to basic stochastic processes tools that can be utilized for performance analysis and stochastic modeling.
6	**Brief Contents**	Review of probability, random variable and expectation Stochastic processes, Discrete-Time Markov Chains, Continuous-Time Markov Chains, Queuing networks
7	**Contents for lab**	

8	**List of text books/references**	1. Introduction to Stochastic Processes‖ , E. Cinlar, Prentice-Hall, 1975. 2. Stochastic Modelling of Queues‖, R. W. Wolf, Prentice-Hall, 1989. 3. Probability & Statistics with Reliability, Queuing and Computer Science Application‖, 2nd ed., Wiley, 2008.

1	**Code of the subject**	CS018
2	**Title of the subject**	Advanced Competitive Programming
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Learning Objectives**	To gain an in-depth knowledge of data structure and algorithms To apply different algorithms in solving real-world problems. To understand the commonly used problem solving techniques
6	**Brief Contents**	Basic Data Structures: Arrays, Strings, Stacks, Queues, Asymptotic analysis (Big-O notation), primality testing, Euclid's GCD Algorithm, Basic Recursion, Greedy Algorithms, Naive string searching, O(n logn) Sorting, Binary Searching, Heaps (priority queue) Advance Data Structure: Disjoint Set Union, Segment Trees, Binary Index Tree (Fenwick tree), Trees traversals, Fundamental of Dynamic Programming, tree dynamic programming GraphAlgorithms:Finding connected components and transitive closures.Shortest-path algorithms (Dijkstra, Bellman-Ford, Floyd-Warshall), Minimum spanning tree (Prim and Kruskal algorithms), Biconnectivity in undirected graphs (bridges, articulation points), Strongly connected components in directed graphs, Topological Sorting. Modular arithmetic including division, inverseAmortized Analysis, Divide and Conquer, Advanced Dynamic Programming problems, Sieve of Eratosthenes Treaps, Persistent Data Structures, HLD, Centroid Decomposition, Computational Geometry, Dynamic Programming Optimizations, Advanced String algorithms (Tries, KMP, Aho-Corasik, Suffix arrays, Suffix trees), Flows (Max-Flow, Min Cost Max Flow)
7	**Contents for lab**	
8	**List of text books/references**	1. Felix Halim and Steven Halim,—Competitive programming 3‖, NUS. 2. Antti and Laaksonen, —Guide to Competitive Programming: Learning and Improving Algorithms Through Contests‖, 78-3319725468, Springer; 1st ed. 2017 3. NarasimhaKarumanchi, —Data Structures and Algorithms made easy‖, CareerMonk Publications; Fifth edition, 2016.

1	**Code of the subject**	CS019
2	**Title of the subject**	Network Programming
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Learning Objectives**	The programming part of the course will be executed through in-class example discussion, homework assignments and term project. Due to the time limit, the lectures will focus mostly on networking concepts and how to achieve them with the selected languages and systems.
6	**Brief Contents**	Module 1: Network and Web basics, Adressing, Naming and DNS Module 2: Socket programming, TCP, UDP programming, Simple client-server programming, Network programming with GUI Module 3: Programming with HTTP for the Internet and WWW, Email, Telnet and FTP Processing XML and JSON data Module 4: Multithreading, multiprocessing, multithreaded servers and clients, Event-driven programming Module 5: Popular Python libraries for your applications
7	**Contents for lab**	
8	**List of text books/references**	1. Abhishek Ratan, Eric Chou, Pradeeban Kathiravelu and Dr. M. O. Faruque Sarker. Python Network Programming. Packt Publishing, 2019. 2. Eric Chou. Mastering Python Networking, 2nd Edition. Packt Publishing, 2018. 3. Josa Manuel Ortega. Mastering Python for Networking and Security. Packt Publishing, 2018. 4. Pradeeban Kathiravelu and Dr. M. O. Faruque Sarker. Python Network Programming Cookbook, 2nd Edition. Packt Publishing, 2017. 5. Dr. M. O. Faruque Sarker and Sam Washington. Learning Python Network Programming, Packt Publishing, 2015. 6. Brandon Rhodes andÂ John Goerzen. Foundations of Python Network ProgrammingÂ 3rd Edition. Apress, 2014.

1	**Code of the subject**	CS020
2	**Title of the subject**	Combinatorial Mathematics
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Learning Objectives**	The course deals with theory and algorithms for solving integer and combinatorial optimization problems. Topics that are covered include models and algorithms for network flow, matching, assignment, matroids, knapsack problems, relaxations, tree search methods, and cutting plane methods.
6	**Brief Contents**	Fundamental concepts of graphs, trees and distance, shortest paths, disjoint paths, matchings and factors, bipartite matching and vertex cover, connectivity and paths, vertex coloring, edge

		colouring, edges and cycles, planar graphs, maximum flow, Gomory-Hu trees.
7	**Contents for lab**	
8	**List of text books/references**	1. C. Papadimitriou and K. Steiglitz, Combinatorial optimization: algorithms and complexity, 2nd Edn., Dover, 1998) 2. A. Schrijver, Combinatorial Optimization, Springer-Verlag, 2002. 3. R. J. Wilson, Introduction to Graph Theory, Longman, 1985.

1	**Code of the subject**	CS021
2	**Title of the subject**	Network Design and Optimization
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Learning Objectives**	To study optimization techniques for use in the domain of computer networks. To analyse network infrastructure requirements and to design and implement the infrastructure for business solutions.
6	**Brief Contents**	Introduction to Graphs and Flows -Network Flow Models - Network Flow Algorithms - Shortest Path Problems - Label Setting (Dijkstra) Methods - Label Correcting Methods - Single Origin/Single Destination Methods - Auction Algorithms - Multiple Origin/Multiple Destination Methods Max-Flow and Min-Cost Flow Problem Max-Flow and Min-Cut Problems - Ford-Fulkerson Algorithm - Price-Based Augmenting Path Algorithms - Transformations and Equivalences - Duality Simplex Methods for Min-Cost Flow Main Ideas in Simplex Methods - Basic Simplex Algorithm - Extension to Problems with Upper and Lower Bounds - Implementation Issues Dual Ascent Methods for Min-Cost Flow Dual Ascent -The Primal-Dual (Sequential Shortest Path) Method -The Relaxation Method -Sensitivity Analysis - Implementation Issues Auction Algorithms for Min-Cost Flow The Auction Algorithm for the Assignment Problem - Extensions of the Auction Algorithm -The Preflow-Push Algorithm for Max-Flow -The Relaxation Method - The Auction/Sequential Shortest Path Algorithm - Nonlinear Network Optimization - Convex Separable Network Problems - Network Problems with Integer Constraints
7	**Contents for lab**	

8	**List of text books/references**	1. Network Optimization: Continuous and Discrete Methods‖, Dimitri Bertsekas, 1998. 2. Network Flows: Theory, Algorithms, and Applications‖, James B. Orlin, Ravindra K. Ahuja, and Thomas L. Magnanti, 1993. 3. Network Optimization Problems: Algorithms, Applications And Complexity‖, Panos M. Pardalos, Ding-Zhu Du, 1993. 4. Routing, Flow and Capacity Designing in Communication and Computer Networks‖, M. Pioro and D. Medhi, Morgan Kaufmann, 2004.

1	**Code of the subject**	CS022
2	**Title of the subject**	Software reliability
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Learning Objectives**	1. Develop reliable software systems. 2. Understand the fault handling and failure forecasting techniques in software systems. 3. Understand different time dependent and time independent software reliability models. 4. Design reliability models for software systems.
6	**Brief Contents**	Basic Ideas of Software Reliability, Hardware reliability vs. Software reliability, Reliability metrics, Failure and Faults – Prevention, Removal, Tolerance, Forecast, Dependability Concept – Failure Behaviour, Characteristics, Maintenance Policy, Reliability and Availability Modeling, Reliability Evaluation Testing methods, Limits, Starvation, Coverage, Filtering, Microscopic Model of Software Risk. Computation of software reliability, Functional and Operational Profile, Operational Profiles – Difficulties, Customer Type, User Type, System Mode, Test Selection - Selecting Operations, Regression Test. Classes of software reliability Models, Time Dependent Software Reliability Models: Time between failure reliability Models, Fault Counting Reliability Models. Time Independent Software Reliability Models: Fault injection model of Software Reliability, Input Domain Reliability Model, Orthogonal defect classification, Software availability Models. Software Reliability Modeling: A general procedure for reliability modeling. Short and Long Term Prediction, Model Accuracy, Analysing Predictive Accuracy – Outcomes, PLR, U and Y Plot, Errors and Inaccuracy, Recalibration – Detecting Bias, Different Techniques, Power of Recalibration, Limitations in Present Techniques, Improvements.
7	**Contents for lab**	

8	**List of text books/references**	1. J.D. Musa, Software Reliability Engineering, McGraw Hill, New York, 2004. 2. H. Pham, Software Reliability, Springer Verlag, New York, 2000. 3. Patric D. T.O Connor, Practical Reliability Engineering, 4th Edition, John Wesley & Sons, 2003. 4. D. Reled, Software Reliability Methods, Springer Verlag, New York, 2001.

1	**Code of the subject**	CS023
2	**Title of the subject**	Computer Vision
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Learning Objectives**	Computer Vision focuses on development of algorithms and techniques to analyze and interpret the visible world around us. This requires understanding of the fundamental concepts related to multi-dimensional signal processing, feature extraction, pattern analysis visual geometric modeling, stochastic optimization etc. Applications range from Biometrics, Medical diagnosis, document processing, mining of visual content, to surveillance, advanced rendering.
6	**Brief Contents**	1. Fundamentals of Computer Vision, Affine and Projective Transformation 2. Convolution and Filtering, Image Enhancement, Histogram Processing, 3. Image Segmentation, Region Growing, Edge Based approaches to segmentation, Graph-Cut, Texture Segmentation 4. Object detection, Filters, edge detection techniques, Caney, Sobel, Prewitt 5. K-Means, K-Medoids Clustering, Optical Flow, Spatio-Temporal Analysis, Dynamic Stereo; Motion parameter estimation. 6. Light at Surfaces; Phong Model; Reflectance Map; Albedo estimation
7	**Contents for lab**	
8	**List of text books/references**	1.Digital Image Processing, 3rd Edition Rafael C. Gonzalez, University of Tennessee, Richard E. Woods, Med Data Interactive 2.Computer Vision: A Modern Approach; D. A. Forsyth and J. Ponce; Pearson Education; 2003. 3. Computer Vision: Algorithms and Applications‖ by Richard Szeliski; Springer-Verlag London Limited 2011.

1	**Code of the subject**	CS024

2	**Title of the subject**	Recommender Systems
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Learning Objectives**	1. To develop state-of-the-art recommender systems that automate a variety of choice-making strategies with the goal of providing affordable, personal, and high-quality recommendations. 2. Discuss how recommender systems and user models are deployed in e-commerce sites and social networks.
6	**Brief Contents**	Introduction: Recommender system functions, Linear Algebra notation: Matrix addition, Multiplication, transposition, and inverses; covariance matrices, Understanding ratings, Applications of recommendation systems, Issues with recommender system. Collaborative Filtering: User-based nearest neighbour recommendation, Item-based nearest neighbour recommendation, Model based and pre-processing based approaches, Attacks on collaborative recommender systems. Content-based recommendation: High level architecture of content-based systems, Advantages and drawbacks of content-based filtering, Item profiles, discovering features of documents, obtaining item features from tags, Representing item profiles, Methods for learning user profiles, Similarity based retrieval, Classification algorithms. Knowledge based recommendation: Knowledge representation and reasoning, Constraint based recommenders, Case based recommenders. Hybrid approaches: Opportunities for hybridization, Monolithic hybridization design: Feature combination, Feature augmentation, Parallelized hybridization design: Weighted, Switching, Mixed, Pipelined hybridization design: Cascade Meta-level, Limitations of hybridization strategies. Evaluating Recommender System: Introduction, General properties of evaluation research, Evaluation designs, Evaluation on historical datasets, Error metrics, Decision-Support metrics, User-Centred metrics. Recommender Systems and communities: Communities, collaboration and recommender systems in personalized web search, Social tagging recommender systems, Trust and recommendations, Group recommender systems.
7	**Contents for lab**	
8	**List of text books/references**	1. Dietmar Jannach, Markus Zanker, Alexander Felfernig, Gerhard Friedrich, “Recommender Systems: An Introduction”, Cambridge University Press (2011). 2. Francesco Ricci, Lior Rokach, Bracha Shapira, Paul B. Kantor, “Recommender Systems Handbook”, Springer (2011). 3. Nikos Manouselis, Hendrik Drachsler, Katrien Verbert, Erik Duval, “Recommender Systems for Learning”, Springer.

1	**Code of the subject**	CS025

2	**Title of the subject**	Modern Cryptography
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Learning Objectives**	To make the students understand the process of deciphering coded messages without being told the key. To study of codes and the art of writing and solving them. To give motivation towards recent research development in the field of cryptography, cryptanalysis, and steganography. Overall this course explores modern cryptographic (code making) and cryptanalytic (code breaking) techniques in detail.
6	**Brief Contents**	Number Theory Basics Modular arithmetic Fields, Binary Fields Primes, GCD and Chinese reminder theorems Extended Euclidean Algorithm and application Fermat's Little Theorem and application Euler Phi function, Block Ciphers in Mathematical way, DES Historical Ciphers (at least 7) Public Key Cryptography, RSA, Two fish.
7	**Contents for lab**	
8	**List of text books/references**	1. "Cryptography: Theory and Practice", Third Edition, by Douglas R. Stinson, CRC Press, Taylor and Francis Group. 2. "Handbook of Applied Cryptography", Fifth Printing, by Alfred J. Menezes, Paul C. van Oorschot, and Scott A. Vanstone, CRC Press. 3. "Cryptography and Network Security: Principles and Practices", Sixth Edition, by William Stallings. 4. The Code Book- The secret history of Codes & Code-breaking by Simon Singh.

1	**Code of the subject**	CS026
2	**Title of the subject**	Robot Motion Planning
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Learning Objectives**	To study algorithms that reason about the movement of physical or virtual entities, To generate sequences of motions for many kinds of robots, robot teams, animated characters, and even molecules.
6	**Brief Contents**	Module 1: An overview of robot motion planning problems. Module 2: Review of basic kinematics of rigid body motion. The configuration space of a rigid body.The classical motion planning paradigms: – the roadmap, the potential field method, – the cellular decomposition and approximate cellular decomposition approaches Module 3: Graph search and discrete planning algorithms. Sensor-Based Motion Planning Algorithms- the "Bug"

		algorithms - the TangentBug algorithm - the incremental Voronoi Graph - the D∗ algorithm Module 4: Potential field based methods, wave front planners. Non-holonomic systems and planning with kinematic constraints. Module 5: Motion planning for Multi robotic systems, motion planning in 3D
7	**Contents for lab**	
8	**List of text books/references**	1. Planning Algorithms by Steve LaValle (Cambridge Univ. Press, New York, 2006). 2. Principles of Robot Motion: Theory, Algorithms, and Implementations (by Howie Choset, Kevin Lynch, Seth Hutchinson, George Kantor, Wolfram Burgard, Ly-dia Kavraki, and Sebastian Thrun). 3. Probabilistic Robotics (by Sebastian Thrun, Wolfram Burgard, and Dieter Fox Lynch). MIT Press, 2005. 4. Robot Motion Planning by J.C. Latombe.

1	**Code of the subject**	CS027
2	**Title of the subject**	Optimization Techniques
3	**Any prerequisite**	
4	**L-T-P**	3-1-0
5	**Learning Objectives**	It introduces a new paradigm of computing and solving problems. It has great applications in Artificial Intelligence, Data Mining, Machine Learning, and real-world design and optimization problems.
6	**Brief Contents**	The basics of linear programming (LPP), graphical and simplex methods, Big-M and two-phase techniques, special cases of LPP, duality theory, sensitivity analysis, transportation models, assignment models, integer programming, dynamic programming, non-linear programming, Kuhn-Tucker conditions, quadratic programming, shortest path problem, minimum spanning tree problem, maximum flow problem
7	**Contents for lab**	
8	**List of text books/references**	1. F.S. Hillier, G.J. Lieberman, Introduction to Operations Research, McGraw-Hill. 2. Dimitris Bertsimas, John N. Tsitsiklis, Introduction to Linear Optimization, Athena Scientific. 3. Stephen Boyd, Lieven Vandenberghe, Convex Optimization, Cambridge University Press. 4. Ravindran, Phillips, Solberg, Operations Research: Principles and Practice, Wiley.

1	**Code of the subject**	CS028
2	**Title of the subject**	Game Theory and Applications
3	**Any prerequisite**	

4	**L-T-P**	3-0-0
5	**Learning Objectives**	1. Understanding the basic game theory concepts, including utility, strategies, and Nash equilibrium. 2. Knowledge of advanced game theory concepts, such as repeated games, signalling games, and mechanism design. 3. Understanding the limitations of game theory and its relationship to other decision-making frameworks. 4. Developing critical thinking skills and the ability to apply game theory to evaluate and design strategies in different domains. 5. Knowledge of the use of game theory in various fields, such as economics, political science, and computer science.
6	**Brief Contents**	Introduction to Game Theory, Dominant Strategies and Nash Equilibrium, Alternate Strategies: Maximin, Maximax, and Minimax Regret Solvability, N-Player Games, Mixed Strategy Nash Equilibria, Subgame Perfection in Discrete Choice Games, Continuous Games and Imperfect Competition, Infinitely Repeated Games, Tacit Collusion: An application of Infinites Repeated Games, imperfect Information: Simultaneous-play, ayesian Games, Applications of Bayesian Games: Auctions and Voting, Cournot's Duopoly with Imperfect Information 3.Radio Spectrum, With Arbitrary Distribution of Valuations, Extensive Form Game with Perfect Information, Stackelberg Model of Duopoly, Buying Votes, Committee DecisionMaking, Repeated games, The Prisoner's Dilemma, General Result, Supermodular Game and Potential Game, Supermodular Game and Potential Game, Wireless Networks: Resource Allocations, Admission Control, Routing in Sensor and AdHoc Networks, Modeling Network Traffic and Strategic Network Formation, Rubinstein Bargaining Model with Alternating Offers, Nash Bargaining Solution, Relation of Axiomatic and Strategic Model, Auction and Mechanism Design with Applications, Revenue Equivalence, Risk Averse Bidders, Asymmetries among Bidders, Mechanism, Optimal Mechanism
7	**List of text books/references**	1. Nisan Roughgarden, Tardos, Vazirani (eds), Algorithmic Game Theory, Cambridge University, 2007 2. Maschler, Michael, Shmuel Zamir, and Eilon Solan. Game theory. Cambridge University Press, 2020. 3. Narahari, Yadati. Game theory and mechanism design. Vol. 4. World Scientific, 2014.

1	**Code of the subject**	CS029
2	**Title of the subject**	Human - Computer Interaction
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Learning Objectives**	The topics covered in the course includes the engineering life cycles for design of interactive systems, computational design framework (as part of the life cycle), components of the framework including the computational models of users and systems, and evaluation of such systems (with or without users).

6	**Brief Contents**	Introduction to user-centric design – case studies, historical evolution, issues and challenges and current trend, Engineering user-centric systems – relation with software engineering, iterative life-cycle, prototyping, guidelines, case studies, User-centric computing – framework, introduction to models, model taxonomy, Computational user models (classical) – GOMS, KLM, Fitts' law, Hick-Hymans law Computational user models (contemporary) 2D and 3D pointing, constrained navigation,mobile typing, touch interaction, Formal models – case study with matrix algebra, specification and verification of properties, formal dialog modeling, Empirical research – research question formulation, experiment design, data analysis, statistical significance test, User-centric design evaluation – overview of evaluation techniques, expert evaluation, userevaluation, model-based evaluation with case studies
7	**Contents for lab**	
8	**List of text books/references**	1. A. Dix, J. Finlay, G. D. Abowd and R. Beale, Human Computer Interaction, 3rd edition, Pearson Education, 2005. References: 1. J. Preece, Y. Rogers, H. Sharp, D. Baniyon, S. Holland and T. Carey, Human Computer Interaction, Addison-Wesley, 1994. 2. C. Stephanidis (ed.), User Interface for All: Concepts, Methods and Tools. Lawrence Erlbaum Associates, 2001. 3. J. M. Caroll (ed.), HCI Models, Theories and Frameworks: Towards a Multidisciplinary Science (Interactive Technologies), Morgan Kauffman, 2003. 4. W. O Galitz, The Essential Guide to User Interface Design, John Wiley & Sons, Inc, 2002 (Indian Edition). 5. B. Shneiderman, Designing the User Interface, Addison Wesley, 2000 (Indian Reprint).

1	**Code of the subject**	CS030
2	**Title of the subject**	Randomized Algorithms
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Learning Objectives**	To use discrete probability theory to describe and model randomized processes and algorithms, to use discrete probability to analyze the performance of deterministic and randomized algorithms, to design randomized algortihms that solve computational problems of moderate difficulty, to know several standard tail inequalities (Markov inequality, Chebyshev inequality, Chernoff bound) and be able to apply them to analyze perfomance of randomized algorithms.
6	**Brief Contents**	Random numbers: Properties of a random sequence. Generating uniform random numbers: the linear congruential method and others. Statistical tests for random numbers: Chi-square test, Kolmogorov-Smirnov test, empirical / theoretical / spectral tests. Non-uniform random sequences. Tools and techniques of

		randomized algorithmics: game theoretic techniques, moments and deviations, tail inequalities, the probabilistic method: Lovasz Local Lemma, Markov chains and random walks, algebraic techniques. Applications: Data structures, hashing, linear programming, computational geometry problems, graph problems, approximate algorithms, parallel and distributed algorithms, cryptography, online algorithms. Derandomization techniques.
7	**Contents for lab**	
8	**List of text books/references**	1. Randomized Algorithms, by Motwani and Raghavan, Cambridge University Press, 1995. 2. Probability and Computing: Randomized Algorithms and Probabilistic Analysis, by Mitzenmacher and Upfal, Cambridge University Press, 2nd edition, 2017. Reference Books: 1. Computational Geometry: Algorithms and Applications, by Mark de Berg, Otfried Cheong, Marc van Kreveld, and Mark Overmars, 3rd edition, Springer-Verlag, 2008. 2. Algorithmic and Analysis Techniques in Property Testing, by Dana Ron. Found. Trends Theor. Comput. Sci. 5, 2 (February 2010), 73-205. 3. Mining of Massive Datasets, by Leskovec, Rajaraman, and Ullman

CODE WITH EExxx

1	**Code of the subject**	EE101
2	**Title of the subject**	Fundamentals of Electrical and Electronics
3	**Any prerequisite**	NA
4	**L-T-P**	3-0-2
5	**Learning Objectives**	After the completion of the course, the students will be able to: • Demonstrate the use of semiconductor diodes in various applications. • Discuss and explain the working of transistors, their configurations and applications. • Apply network laws and theorems to solve electric circuits. • Analyze transient and steady state response of DC circuits. • Explain and analyse the behaviour of transformer. • Elucidate the principle and characteristics of DC motor and DC generator.
6	**Brief Contents**	Fundamental laws of electrical engineering circuit parameters, Classification of devices of an electrical circuit; Basic devices: resistors, controlled sources, diodes, capacitors and inductors, ideal transformers, Methods of Analysis, DC Network Theorems, Basic circuit analysis methods: nodal, mesh and modified nodal-analysis; Transient analysis of RL, RC, and RLC circuits, Three Phase Circuits and Power Measurements, Single Phase Transformers, Three Phase Induction Machines, DC Machines Semiconductor Materials: Ge, Si, and GaAs; n-Type and p-Type Materials; Semiconductor Diode and types; Construction and application of Bipolar Junction Transistors; Common-Base Configuration, Common-Emitter Configuration, Common-Collector Configuration; Clipper and Clamper, Rectifiers, Basics of MOSFET.
7	**Contents for lab**	Familiarization with CRO, DSO and Electronic Components, Diodes characteristics - Input-Output and Switching, BJT and MOSFET Characteristics, Zener diode as voltage regulator, Rectifiers, Clippers and Clampers, Network laws and theorems, Measurement of R,L,C parameters, A.C. series and parallel circuits, Measurement of power in 3 phase circuits, Reactance calculation of variable reactance choke coil, open circuit and short circuit tests on single phase transformer, Starting of rotating machines.
8	**List of textbooks/references**	**Text/ Reference Books:** • Electronic Devices and Circuit Theory by R.L. Boylestad and L. Nasheisky, Pearson. • Basic Electrical Engineering by J. Nagrath and D. P. Kothari, TATA McGraw-Hill. • Electric Circuits by D. A. Bell, Oxford Higher Education. • Modern Semiconductor Device Physics by S.M. Sze, Wiley. • Electrical Technology by E. Hughes, Pearson Education. • Electrical Engg Fundamentals by V. Del Toro, PHI Learning.

		• Electronic Devices and Circuits by Milliman, J. and Halkias, C.C., Tata McGraw Hill. • Introduction to Electrical Engineering by Naidu, M.S. and Kamashaiah, S., Tata McGraw Hill.

1	**Code of the subject**	EE102
2	**Title of the subject**	Engineering Design Principles
3	**Any prerequisite**	NA
4	**L-T-P**	2-0-2
5	**Learning Objectives**	The course should enable the students to: • Design and implement sensor and transducer systems for diverse engineering applications. • Develop and simulate signal conditioning circuits for accurate measurement and data processing. • Design data acquisition systems for monitoring and efficient data collection. • Create and test circuit designs for instrumentation systems, including calibration and error analysis.
6	**Brief Contents**	This course will cover an introduction to engineering design principles, focusing on measurement, accuracy, precision, and calibration. It will explore the fundamentals of design and simulation, different measurement standards and international calibration practices, design and integration of data acquisition systems, and signal conditioning techniques.
7	**Contents for lab**	In this lab, students will learn simulation tools, design and simulate sensor circuits, signal conditioning systems, and data acquisition setups using hardware/ software. They will develop circuits for amplifying, filtering, and converting sensor signals for accurate measurement. The lab will provide hands-on experience with the design, simulation, and optimization of measurement systems for real-world applications.
8	**List of textbooks/references**	• Fundamentals of Engineering Drawing by W.J. Luzadder and J.M. Duff, PHI. • Engineering Design - “A Materials and Processing Approach” by Dieter, George E., McGraw Hill. • Introduction to Measurement and Instrumentation" by Arthur P. Morris • The Art of Electronics" by Paul Horowitz and Winfield Hill • Measurement and Instrumentation: Theory and Application" by Alan S. Morris and Reza Langari • Electronic Circuit Design: From Concept to Implementation" by Nihal Kularatna

1	**Code of the subject**	EE103
2	**Title of the subject**	Digital Electronics
3	**Any prerequisite**	NA
4	**L-T-P**	3-0-2
5	**Learning Objectives**	After the completion of the course, the students will be able to: • Recognize and apply the number systems and Boolean algebra. • Reduce Boolean expressions and implement them with Logic Gates. • Analyze, design and implement combinational and sequential circuits
6	**Brief Contents**	Boolean algebra, K-maps, logic gates, Number Systems, Design of combinational circuits, Design of sequential circuits, Introduction to digital logic families, Data processing and conversion: Sample and hold circuits, ADCs and DACs; Basic memory circuits ROM, RAM and PLA.
7	**Contents for lab**	Implementation of digital logic using switching circuits, Study of universal gates, Design of a 1-bit Full Adder/Subtractor using logic gates, Design and implementation of a 4-bit binary ripple, adder using logic gates, 4 X 3 bit binary multiplier using logic gates, Study of code converters (BCD to excess-3, binary to gray and gray to binary), Study of combinational MSI circuits – 1-bit half/full, adder, 1-bit half/full subtractor and 1-bit magnitude, comparator, Study of sequential circuits – Implementation of Flip-Flops, Design of a synchronous decade counter, Design of 4-bit parallel input serial output (PISO), shift-register.
8	**List of textbooks/references**	**Text/ Reference Books:** • Digital Circuits and Logic Design by S. Lee, Prentice Hall India. • Digital Principles and Applications by D. P. Leach, A. P. Malvino and G. Saha, McGraw Hill Education. • Digital Design by M. M. Mano and M.D. Ciletti, Pearson, Prentice Hall. • Digital Principles and Design by Donald D Givone, McGraw-Hill. • Digital Design: Principles and Practices by John F Wakerly, Pearson. • Digital Electronics: Principles Design and Applications by AK Maini. • Digital Integrated Electronics by H. Taub and D. Schilling, McGraw Hill.

1	**Code of the subject**	EE104
2	**Title of the subject**	Hardware Workshop
3	**Any prerequisite**	NA
4	**L-T-P**	**2-0-2**

5	**Learning Objectives**	• Gain hands-on experience in soldering, PCB design, and assembly of electronic components for practical applications. • Learn to use testing and troubleshooting tools such as oscilloscopes and multimeters to diagnose and repair circuit faults. • Develop skills in designing and fabricating simple electronic circuits and custom PCBs for real-world electronics systems. • Apply safety protocols and best practices in the handling of electronic components and equipment during hardware assembly and testing.
6	**Brief Contents**	This course will introduce students to the fundamental concepts of hardware design and construction within electronics systems. It will cover the basic tools and techniques used in electronics prototyping, including soldering, PCB design, and assembly. Students will learn to work with electronic components such as resistors, capacitors, diodes, transistors, and ICs. The course will also explore the process of designing and fabricating simple electronic circuits for real-world applications. Practical sessions will cover building, testing, and modifying circuits in a workshop environment. Students will also work on designing custom PCBs using design software. Finally, students will complete a project that integrates the knowledge gained to design, test, and assemble a functional electronic system.
7	**Contents for lab**	In this lab, students will practice soldering and assembling basic electronic circuits, learning to identify and place components correctly. They will design and fabricate simple PCBs using appropriate design software and tools. Testing and troubleshooting exercises will focus on diagnosing faults using oscilloscopes, multimeters, and power supplies.
8	**List of textbooks/references**	• The Art of Electronics by Paul Horowitz and Winfield Hill • Practical Electronics for Inventors by Paul Scherz and Simon Monk • Electronic Principles by Albert Paul Malvino • PCB Design for Real-World Design by Chris Schroeder

1	**Code of the subject**	EE207
2	**Title of the subject**	Signals & Systems
3	**Any prerequisite**	Engineering Mathematics
4	**L-T-P**	3-1-0
5	**Learning Objectives**	This course trains students for an intermediate level of fluency with signals and systems in both continuous time and discrete time, in preparation for more advanced subjects in digital signal

		processing (including audio, image and video processing), communication theory, and system theory, control and robotics
6	**Brief Contents**	Classification of signals, Continuous-time and discrete-time signals, Basic system properties, Discrete-time LTI systems: convolution sum, Continuous-time LTI systems, Properties of LTI systems, Causal LTI systems described by difference equations (Natural, Forced, and Complete Response), Representation of Periodic (Continuous Time & Discrete-Time) Signals Using Fourier Series, Continuous-time Fourier transform, the discrete-time Fourier transform (DTFT), discrete Fourier transform (DFT) Sampling theorem, Laplace transform, z-transform.
7	**Contents for lab**	NA
8	**List of textbooks/references**	• Signals and systems by A.V. Oppenheim, A.S. Willsky and S. H. Nawab, Prentice Hall India. • Linear Systems and Signals by B. P. Lathi, Oxford University Press. • Signals & Systems by Simon &Haykins, John Wiley & Sons. • Digital Signal Processing: Principles, Algorithms and Applications by Proakis, PHI.

1	**Code of the subject**	EE202
2	**Title of the subject**	Network Analysis & Synthesis
3	**Any prerequisite**	Engineering Mathematics-1 and Engineering Mathematics-2
4	**L-T-P**	3-1-0
5	**Learning Objectives**	• To make the students capable of analyzing any given electrical network. • To make the students learn how to synthesize an electrical network from a given impedance/admittance function. • Apply the knowledge of basic circuit law and simplify the network using reduction techniques. • Analyze the circuit using Kirchhoff's law and Network simplification theorems. • Infer and evaluate transient response, Steady state response, and network functions. • Obtain the maximum power transfer to the load and analyze the series resonant and parallel resonant circuits.
6	**Brief Contents**	Network concept, Elements and sources, Kirchoff's laws, Tellegen's theorem, Network equilibrium equations, Node and Mesh method, Source superposition, Thevenin's and Norton's theorems, Network graphs, First and second-order networks, State equations, Transient response, Network functions, Determination of the natural frequencies and mode vectors from

		network functions, Sinusoidal steady-state analysis, Maximum power transfer theorem, Resonance, Equivalent and dual networks, Design of equalizers, Two-port network parameters, Interconnection of two-port networks, Barlett's bisection theorem, Image and Iterative parameters, Design of attenuators, Two-terminal network synthesis, Properties of Hurwitz polynomial and Positive real function, Synthesis of LC, RC and RL Networks, Foster Forms and Cauer Forms.
7	**Contents for lab**	NA
8	**List of textbooks/references**	• Engineering Circuit Analysis by Hayt W. H., Kemmerly J. E. and Durbin S. M., Tata McGraw-Hill. • Network Analysis by Valkenberg V., PHI. • Network Analysis and Synthesis BY Kuo F. F., Wiley India.

1	**Code of the subject**	EE203
2	**Title of the subject**	Microelectronics: Devices and Materials
3	**Any prerequisite**	EE101
4	**L-T-P**	3-0-2
5	**Learning Objectives**	After the completion of the course, the students will be able to understand and have a mental picture of holes, electrons, density of states, doping, majority carriers, minority carriers, Fermi Level, Quasi-Fermi Level, and understand device performance given in terms of energy band diagram or device configuration.
6	**Brief Contents**	Review of materials – Si, Ge, III-V material properties and band structure. Semiconductors and Crystal Structures, Basic Semiconductor Physics, Excess carriers, lifetime, and carrier transport by drift and diffusion, Continuity equation and its solution under different injections, Junction Diode, Bipolar Junction Transistor (BJT), MOS Capacitor, Metal Oxide Semiconductor Field Effect Transistor (MOSFET), Short Channel Effects, Some Important Devices Tunnel Diode, Varactor Diode, Light Emitting Diode (LED), Photodetector, and Solar Cell. Overview of smart materials technology, Characteristics of smart materials such as piezoelectric, Structural modeling and design, Dynamics and control for smart structures, Integrated system analysis, Thermal Management. Smart Sensor, Actuator, and Transducer Technologies, Next-generation materials.
7	**Contents for lab**	NA

8	**List of textbooks/references**	• Solid State Electronic Devices BY Streetman B.G., Banerjee, S.K, Pearson Education. • Introduction to Semiconductor Materials and Devices by Tyagi M.S., John Wiley & Sons. • Semiconductor Devices Physics and Technology by Sze S.M., John Wiley & Sons.

1	**Code of the subject**	EE208
2	**Title of the subject**	Electromagnetic Theory
3	**Any prerequisite**	NA
4	**L-T-P**	3-1-0
5	**Learning Objectives**	The learning objectives of the subject are as follows: • Define the fundamental concepts and principles of electromagnetism • Explain the laws of electrostatics and magnetostatics and apply them to solve problems • Analyze and calculate the electric and magnetic fields of various charge and current distributions • Use Gauss's Law and Ampere's Law to calculate electric and magnetic fields, respectively • Understand the mathematical techniques used in electromagnetic theory, including vector calculus and differential equations • Understand the role of Maxwell's equations in describing the behaviour of electromagnetic fields • Apply electromagnetic theory to real-world problems and communicate findings effectively.
6	**Brief Contents**	Introduction to electromagnetism and its historical development, Coulomb's law and electric field, Gauss's law and its applications, Electric potential and potential difference, Capacitance and dielectrics, Current, resistance, and Ohm's law, Magnetostatics and Biot-Savart law, Ampere's law and its applications, Faraday's law of electromagnetic induction, Maxwell's equations and their interpretation, Electromagnetic waves and their properties, Wave polarization and reflection and refraction of electromagnetic wave, Transmission lines and waveguides, Applications of electromagnetic theory in various fields, such as electronics, telecommunications, and optics.
7	**Contents for lab**	NA
8	**List of textbooks/references**	• Introduction to Electrodynamics by Griffiths, D. J., Pearson. • Field and Wave Electromagnetics by Cheng, D. K., Addison-Wesley. • Engineering Electromagnetics by Hayt, W. H., Buck, J. A., & Buck, J. T., McGraw-Hill. • Elements of Electromagnetics by Sadiku, M. N. O., Oxford University Press.

		• Fields and Waves in Communication Electronics by Ramo, S., Whinnery, J. R., & Van Duzer, T., Wiley. • Advanced Engineering Electromagnetics by Balanis, C. A., Wiley.

1	**Code of the subject**	EE302
2	**Title of the subject**	System Design using HDL
3	**Any prerequisite**	EE103
4	**L-T-P**	3-0-2
5	**Learning Objectives**	• Correctly describe the detailed behavior of given digital logic circuits as defined by VHDL, state diagrams, or other means, including those circuits related to modern computer architecture. • Translate system requirements into a practical digital design, making use of modern engineering tools such as Xilinx Vivado, Verilog HDL, and FPGA prototyping boards. • Demonstrate the ability to modify existing HDL code to meet new system requirements. • Demonstrate hands-on test bench and prototyping skills to ensure that a design meets the specified system requirements.
6	**Brief Contents**	Basic concepts of hardware description languages (VHDL, Verilog HDL), logic and delay modeling, Structural, Data-flow, and Behavioural styles of hardware description, Architecture of event driven simulators, operators, operands, operator types, blocking and non-blocking statements, delay control, generate statement, event control, Sequential Logic Design, FSM, Configuration Specifications, Sub-Programs, Test Benches.
7	**Contents for lab**	HDL code for all the gates, Half Adder, Half Subtractor, Full Adder & Full subtractor, decoder, encoder, mux, demux, code converter, counter, registers etc. and implementation of the same on FPGA.
8	**List of textbooks/references**	• Digital Systems Design Using VHDL by Charles H. Roth, Jr and Lizy Kurian John. • A VHDL Primer by Bhaskar, J., Pearson Education India. • Verilog HDL: A Guide to Digital Design and Synthesis by Samir Palnitkar, Prentice Hall PTR. • A Verilog® HDL Primer, by J. Bhasker. • The Designer's Guide to VHDL by Ashenden, P., Elsevier.

1	**Code of the subject**	EE303
2	**Title of the subject**	Microprocessor and Interfacing

3	**Any prerequisite**	EE103
4	**L-T-P**	3-0-2
5	**Learning Objectives**	Upon completion of this course, the student will be able to: • To develop background knowledge and core expertise in microprocessor. • To study the concepts and basic architecture of 8085, and 8086 processor. • To know the importance of different peripheral devices and their interfacing to 8086. • To know the design aspects of basic microprocessor. • To write assembly language programs in microprocessor for various application
6	**Brief Contents**	Microprocessors-Evolution and Introduction, Microprocessor based system, Origin of Microprocessor, Classification of Microprocessors, Types of Memory, I/O Devices, Technology Improvements Adapted to Microprocessors and Computers, Introduction to 8085 processor, Architecture of 8085, Microprocessor instructions, classification of instructions, Instruction set of 8085, Basic 80x86 Architecture, Role of Microprocessor in Micro Computer, Features of 8086, Internal Block Diagram of 8086, Execution Unit, Bus Interface Unit, Programming of x86 processor, Interrupt mechanism of x86 & Interfacing of chips, Advanced Processor Technologies Interfacing of Data Converters (D-To-A and A-To-D), Programmable Interfacing Devices Like 8255A PPI, 8253/8254 Timer, 8259A PIT, Serial I/O Concepts, SID And SOD, 8251A USART. Interfacing of above chips with 8085.
7	**Contents for lab**	Assembly language programs for 8085 and 8086, Programs involving Arithmetic & logical operations, Programs involving data transfer instructions, Programs involving bit manipulation instructions, Programs involving branch/ loop instructions, Interfacing Experiments.
8	**List of textbooks/references**	• Microprocessors and Interfacing by Douglas V. Hall • The 8051 Microcontroller and Embedded Systems by M.A. Mazidi and J. G. Mazidi, PHI. • The Intel Microprocessors by Barry B. Brey, Prentice Hall. • The 8088 and 8086 Microprocessors by Walter A. Triebel, Avtar Singh, Prentice Hall Inc. • 8086/8088 family: Design, Programming and Interfacing by John Uffenbeck, Prentice Hall. • Advanced Microprocessor and Peripherals, Architecture Programming and Interfacing by A. K. Ray and K. M. Burchandi, Tata McGraw Hill. • Microcontroller and Embedded Systems by M. A. Mazidi, Pearson Education. • 8051 Microcontroller and Embedded Systems by R. Kapadia, Jaico Publishing House. • Fundamentals of Microprocessors and Microcomputers by B. Ram, Dhanpat Rai Publications.

1	**Code of the subject**	EE201
2	**Title of the subject**	Principles of Communication
3	**Any prerequisite**	NA
4	**L-T-P**	3-0-2
5	**Learning Objectives**	• Design /Demonstrate the use of analog and digital modulation techniques. • Analyze and compute the performance of the communication system in presence of noise.
6	**Brief Contents**	Layered view of wireless communication, Historical Background and Applications, Basic tools for communication: Fourier Series/Transform, Analog modulation and demodulation techniques, noise and interference in wireless communication, Probability, random variables and stochastic process, Sampling, Quantization, Delta Modulation, Differential Pulse Code Modulation (DPCM), Baseband Data Transmission, Band-Pass Data Transmission encoding techniques, Principles of Digital Transmission schemes–FSK, BPSK, Error Detection and Correction schemes, Noncoherent Digital Modulation Schemes, M-ary Digital Modulation Schemes
7	**Contents for lab**	To perform analog modulation and demodulation, impact of different parameters on the performance To perform digital modulation and demodulation, impact of different parameters on the performance, To simulate the wireless fading channel, performance analysis (outage, BER) of communication system under different fading channels and noise
8	**List of textbooks/ references**	• Communications Systems by Simon Haykin, John Wiley and Sons. • Fundamentals of Wireless Communication by David Tse • An Introduction to Analog & Digital Communications by Michael Moher Simon Haykin, John Wiley and Sons. • Digital Communications by J. G. Proakis and M. Salehi, McGraw-Hill. • Modern Analog & Digital Communication System by B.P. Lathi • Digital and Analog Communication Systems by K. Sam Shanmugam. • Principle of Communication Systems by Taub & Schilling.

1	**Code of the subject**	EE204
2	**Title of the subject**	Analog Electronics
3	**Any prerequisite**	EE101
4	**L-T-P**	3-0-2

5	**Learning Objectives**	To acquaint the students with the fundamental principles of operation and design of analog circuit building blocks (Diodes, BJT and MOSFET) and their use in analog circuit design. In addition, to get familiar with op-amps applications followed by basic conversion techniques and errors, precision amplifier, logarithmic amplifier, square-root amplifier.
6	**Brief Contents**	MOSFET and BJT models, Transistor Biasing and Thermal Stabilization, Overview of biasing of MOS and BJT amplifiers, Common Source (CS) amplifiers, CS amplifier with source degeneration, common gate amplifers, common drain amplifiers, Brief overview of BJT amplifiers (Common emitter, common base, common collector), MOS and BJT cascode amplifiers, MOS and BJT current mirrors, cascode current mirrors. Differential Amplifiers: MOS and BJT differential pair's large signal analysis, small signal analysis of differential pairs, cascade differential amplifiers, common-mode rejection, and differential amplifiers with active load. Frequency Response, Feedback and Oscillators, OPAMP Basics and Applications.
7	**Contents for lab**	Experiments using BJTs, FETs, op-amps and other integrated circuits: Multistage amplifiers, automatic gain controlled amplifiers, programmable gain amplifiers; frequency response of amplifiers; voltage regulator with short circuit protection; phase-locked loop; waveform generators; filters
8	**List of textbooks/references**	• Microelectronics Circuits by S. Smith, Oxford. • Analysis & Design of Analog Integrated Circuits by P. Gray, P. Hurst, S. Lewis, and R. Meyer, Wiley. • Fundamentals of Microelectronics by Behzad Razavi, Wiley India. • Electronic Devices and Circuit Theory by Boylestad R. L., Pearson Education. • Integrated Electronics by Millman, J. and Halkias, C.C., Tata McGraw-Hill. • Electronic Circuit Analysis and Design by Neamen, Donald A., McGraw-Hill. • Microelectronic Circuits by Sedra A. S. and Smith K. C., Oxford University Press.

1	**Code of the subject**	EE209
2	**Title of the subject**	Control System
3	**Any prerequisite**	EE201
4	**L-T-P**	**3-1-0**
5	**Learning Objectives**	After the completion of the course, the students will be able to: • Develop the mathematical model of the physical systems. • Analyze the response and stability of the closed and open loop systems.

		• Design the various kinds of compensators. • Develop and analyze state space models.
6	**Brief Contents**	Introduction to Feedback Control, Transfer Function, Modelling Electrical, Mechanical, and Electro-mechanical Systems, Block Diagrams, Signal Flow Graph, State Space Representations, Non-linearities, Stability, Routh-Hurwitz Theorem, Steady State Error, Static Error Constants, Type Classification of Transfer Functions, Root Locus: Qualitative Sketching Rules, P, PI, PD, PID, Lag, Lead, and Lag-Lead Compensator Design, Notch Filters, Frequency Response: Bode Plots, Nyquist Stability Criterion, Gain Margin, Phase Margin, Sensitivity, Design Using Frequency Response, State Space Methods: Pole Placement, Observer Design, and Separation Principle
7	**Contents for lab**	N.A.
8	**List of textbooks/references**	• Control System Engineering, by N. S. Nise (Wiley) • Modern Control Engineering, by K. Ogata (Prentice Hall) • Modern Control Systems, by R. C. Dorf and R. H. Bishop (Prentice Hall) • Control Systems Engineering by Nagrath, I. J., and Gopal, M., New Age International Publishers. • Automatic Control Systems by Benjamin C. Kuo, Pearson education. • Digital Control of Dynamic Systems by G F Franklin, J D Powell and M Workman. • Digital Control and State Variable Methods by M. Gopal, McGraw-Hill.

1	**Code of the subject**	EE301
2	**Title of the subject**	Digital Signal Processing
3	**Any prerequisite**	EE201
4	**L-T-P**	3-0-2
5	**Learning Objectives**	After the completion of the course, the students will be able to: • Understand the analytical tools such as Fourier transforms, Discrete Fourier transforms, Fast Fourier Transforms, and Z-Transforms required for digital signal processing. • Get familiarized with various structures of IIR and FIR systems. Design and realize various digital filters for digital signal processing. • Understand the applications of DSP in speech processing and spectrum analysis.

6	**Brief Contents**	Review of z-transform and DFT algorithms. Radix-2 algorithm, decimation-in-time, decimation-in-frequency algorithm, signal flow graph, Butterflies, computations in one place, bit reversal, examples for DIT & DIF FFT Butterfly computations and exercises. Basic concepts of IIR and FIR filters, difference equations, design of Butterworth IIR analog filter using impulse invariant and bilinear transform, design of linear phase FIR filters no of taps, rectangular, Hamming and Blackman windows. Effect of quantization. Digital Signal Processor: Elementary idea about the architecture and important instruction sets of TMS320C 5416/6713 processor, writing of small programs in assembly Language.
7	**Contents for lab**	Understanding mathematical operations on discrete signals. Sketch the magnitude and phase response of DFT, Inverse DFT, and FFT of discrete-time signals. Calculate linear and circular convolution of discrete signals. Model IIR and FIR filters using window techniques, architecture of a DSP processor.
8	**List of textbooks/references**	• Digital Signal Processing: Principles, Algorithms and Applications by Proakis, J. & D. G. Manolakis, Pearson Education. • Digital Signal Processing by Alan V. Oppenheim and Ronald W. Schafer, PHI. • Digital Signal Processing "A – Computer Based Approach" by Sanjit K. Mitra, Tata Mc Graw Hill. • Digital Signal Processing-implementation using DSP microprocessors with examples from TMS320C54XX, Avtar Singh & S. Srinivasan, Cengage Learning.

1	**Code of the subject**	EE205
2	**Title of the subject**	VLSI Design
3	**Any prerequisite**	EE101
4	**L-T-P**	3-0-2
5	**Learning Objectives**	Upon completion of this course, the student will be able to: • Use MOS structures in basic digital circuits. • Describe the general processing steps required to fabricate an integrated circuit. • Implement various CMOS logic circuits. • Design simple circuits to meet stated operating specifications.
6	**Brief Contents**	Introduction to VLSI, MOS Transistor Theory, MOS Structure and its operation, I-V Characteristics, Scaling, Short-Channel Effects, Second order effects, MOS Device Models, Small Signal operation and Equivalent Circuit of MOS Transistor, MOS Capacitors, NMOS & CMOS Process technology, Electrical Design Rules, Stick Diagram, Layout Design, Resistive Load & Active Load MOS Inverters, NMOS Inverters, CMOS Inverters, Interconnect Parasitics, Propagation Delay,

		Static and Dynamic Power Dissipation, Noise Margin, Logic Threshold Voltage, Logical effort, Driving large loads, MOS Logic Circuits with Depletion NMOS loads, CMOS Logic Circuits, CMOS logic Styles, Realization of simple gates, Complex logic circuits, Pass Gate, Transmission Gate.
7	**Contents for lab**	Familiarization with Circuit design/simulation tools (Cadence/Mentor/Tanner Tools) for schematic and layout entry, Circuit simulation using SPICE. DC transfer Characteristics of Inverters, Transient response, calculating propagation delays, rise and fall times, Circuit design of inverters, Complex gates with given constraints.
8	**List of textbooks/references**	• Principles of CMOS VLSI Design by Neil H. E. Weste, Kamran Eshraghian, Addison Wesley. • CMOS Digital Integrated Circuits: Analysis and Design by Sung-Mo Kang and Yusuf Leblebici. • Basic VLSI Design by Pucknell, D.A. and Eshraghian, K., PHI. • Essentials of VLSI Circuit and System by Eshraghian, K., Pucknell, D. A. and Eshraghian, S., PHI. • Introduction to VLSI Circuits and Systems by Uyemera, P.J., John Wiley & Sons.

1	**Code of the subject**	EE206
2	**Title of the subject**	Wireless Communication
3	**Any prerequisite**	EE207
4	**L-T-P**	**3-1-0**
5	**Learning Objectives**	• Apply Cellular concepts to evaluate the signal reception performance in a cellular network. • To design cellular network with given quality of service constraints. • Determine the appropriate model of wireless fading channel based on the system parameters and the property of the wireless medium. • Analyze and design receiver and transmitter diversity techniques. • Application of Fundamental Digital Communication Concepts in Fading Channel. Understanding suitable Modulation Schemes for Wireless Channel

6	**Brief Contents**	Introduction to cellular and Mobile communication systems, Wireless channel models, Cellular systems concepts, principles, system design fundamentals, traffic theory. Characterization of wireless radio channel, Transmit and receive Diversity techniques-SC, MRC, EGC, Switch & Stay, BER and Outage with Diversity, MIMO fundamentals-channel model and performance analysis, Equalization, Capacity of fading Channels: Multi User Capacity, Multiple access techniques: TDMA, FDMA, spread spectrum techniques, Cellular CDMA, Wideband CDMA, OFDMA, Multiple access Performance analysis, Wireless Networks and Standards: GSM, CDMA Cellular standard, 3G, 4G, 5G: challenges and Key technologies
7	**Contents for lab**	NA
8	**List of textbooks/references**	• Wireless Communication by Andrea Goldsmith, Cambridge University Press. • Principles of Modern Wireless Communication Systems Theory and Practice by Aditya K Jagannathan, McGraw-Hill India. • Fundamentals of Wireless Communication by David TSE and Pramod Viswanathan, Cambridge University Press. • Wireless Communications: Principles and Practice by Theodore Rappaport, Pearson. • Wireless Communication by Andreas. F. Molisch, John Wiley and Sons. • Wireless Communication and Networking by Mark and Zhuang, PHI

1	**Code of the subject**	EE304
2	**Title of the subject**	IoT and Applications
3	**Any prerequisite**	NA
4	**L-T-P**	3-0-2
5	**Learning Objectives**	After the completion of the course, the students will be able to: • Understand the definition and significance of the Internet of Things. • Discuss the architecture, operation, and business benefits of an IoT solution. • Explore the relationship between IoT, cloud computing, and big data. • Identify how IoT differs from traditional data collection systems.
6	**Brief Contents**	Introduction to IoT: Sensing, Actuation, Basics of Networking, Communication Protocols, Sensor Networks, Machine-to-Machine Communications, Interoperability in IoT, Introduction to Arduino Programming, Integration of Sensors and Actuators with Arduino, Introduction to Python programming, Introduction to Raspberry Pi, Implementation of IoT with Raspberry Pi, Cloud Computing, Sensor-Cloud, Fog Computing, Smart Cities and Smart Homes, Industrial IoT, Case Study: Agriculture, Healthcare, Activity Monitoring.

7	**Contents for lab**	Coding for the various components of the IoT system, coming up with a micro-controller-based embedded system, building and testing it extensively, the various programming aspects of interfacing with the physical world, system design, microcontrollers, coming up with new and creative ways to solve a problem using coding.
8	**List of textbooks/references**	• The Internet of Things: Enabling Technologies, Platforms, and Use Cases by Pethuru Raj, Anupama C. Raman, CRC Press. • Internet of Things: A Hands-on Approach by ArshdeepBahga, Vijay Madisetti, Universities Press. • Introduction to internet of things (NPTEL Course)", Sudip Misra. (https://nptel.ac.in/syllabus/106105166/)

1	**Code of the subject**	EE305
2	**Title of the subject**	RF Circuit and Antenna Design
3	**Any prerequisite**	NA
4	**L-T-P**	3-0-2
5	**Learning Objectives**	The learning objectives of the subject will be to • Understand the properties of electromagnetic waves and their relevance • Analyze and design RF circuits using various passive and active components, including filters, amplifiers, and mixers. • Understand the principles of impedance matching. • Understand the concept of noise in RF circuits. • Understand the principles of antenna design, including antenna types, radiation patterns, and impedance matching.
6	**Brief Contents**	Introduction to RF circuit and antenna design, Passive RF components, including resistors, capacitors, and inductors, RF filters and their design principles, Amplifiers and their design principles, including noise figure and gain, Mixers and their design principles, including image rejection and spurious response, Impedance matching techniques and design of matching networks, Introduction to antenna design and its applications, Fundamental principles of antennas, including radiation pattern and impedance matching Analysis and design of various antenna structures, such as dipole, monopole, patch, and slot antennas, Simulation and design of RF circuits and antennas using CAD tools, such as HFSS and ADS
7	**Contents for lab**	Introduction to RF circuit and antenna design software tools, such as HFSS and ADS, Analysis and design of resonant circuits, filters, and transmission lines, analysis and design of amplifiers and mixers, design and simulation of matching networks using lumped and distributed elements, Antenna fundamentals: analysis and design of dipole and monopole antennas, Antenna types and characteristics: analysis and design of patch, slot, and horn antennas, application of RF circuit and antenna design principles to a real-world problem, such as designing a wireless communication or radar system.

8	**List of textbooks/references**	• Microwave Engineering by Pozar, D. M., Wiley. • Antenna Theory: Analysis and Design by Balanis, C. A., Wiley. • Antenna Theory and Design by Stutzman, W. L., & Thiele, G. A., Wiley. • Microstrip Lines and Slot lines by Gupta, K. C., & Garg, R., Artech House. • RF Microelectronics by Razavi. • RF Circuit Design by Bowick. • Foundations for Microwave Engineering by Collin

1	**Code of the subject**	EE306
2	**Title of the subject**	Microcontroller and Embedded Systems
3	**Any prerequisite**	Nil
4	**L-T-P**	3-0-2
5	**Learning Objectives**	The student will be able to: • Understand the concept of embedded system, microcontroller, different components of microcontroller and their interactions. • Get familiarized with programming environment to develop embedded solutions. • Program ARM microcontroller to perform various tasks. • Understand the key concepts of embedded systems such as I/O, timers, interrupts and interaction with peripheral devices.
6	**Brief Contents**	8051 Microcontroller, PIC Microcontrollers, RM7TDMI Microcontrollers, Hardware Interfacing: Interfacing with LEDs, Seven Segment, Sensors, Basic concepts of LCD, ADC, DAC, Relays etc. and their interfacing to microcontroller. Introduction to Embedded Systems: Background, History and classification, Core of the embedded system-general purpose and domain-specific processors, ASICs, PLDs, COTs; Communication Interface, Embedded Firmware Design and Development, RTOS Based Embedded System Design.
7	**Contents for lab**	ALP for all ALU, generate clock, display a string, interface of seven segment display, DAC etc. Arduino and Raspberry Pi Microcontroller based Projects.
8	**List of textbooks/references**	• The 8051 Microcontroller: Architecture, programming and applications, by Ayala J.K., Penram International. • The 8051 Microcontroller and Embedded Systems by Mazidi, E. and Mazidi, F., Prentice-Hall of India. • Embedded system Design using PIC18Fxxx by Peatman J., Prentice Hall. • ARM System-on-Chip Architecture by Steve Furber, PEARSON.

		• ARM System Developer's Guide Designing and Optimizing System Software by Andrew N. Sloss, Morgan Kaufman Publication. • Embedded Systems Design: An Introduction to Processes, Tools & Techniques by Arnold S. Berger. • PIC Microcontroller and Embedded Systems using assembly and C for PIC18 by Muhammad Ali Mazidi, Rolin D. McKinlay. Dann.

1	**Code of the subject**	EE401
2	**Title of the subject**	Trustworthy AI and Machine learning
3	**Any prerequisite**	Engineering Mathematics I, Engineering Mathematics –II, Object-oriented Programming
4	**L-T-P**	3-0-2
5	**Learning Objectives**	To equip students with the knowledge to develop ethical and reliable AI systems.
6	**Brief Contents**	Trustworthy AI and Machine Learning delves into the ethical considerations and challenges in AI systems, focusing on fairness, transparency, and accountability. Students will explore techniques for bias detection and mitigation, ensuring that AI models are developed without discriminatory outcomes. The course covers explainability and interpretability methods, making AI systems more understandable for users. Additionally, it examines the robustness and security of machine learning models against adversarial attacks and other vulnerabilities.
7	**Contents for lab**	The lab component focuses on hands-on experience with implementing AI and machine learning models while addressing ethical challenges. Students will work with real-world datasets to identify and mitigate bias, ensuring fairness in model predictions. They will also apply techniques for model explainability and interpretability.
8	**List of textbooks/references**	• Fairness and Machine Learning by Solon Barocas, Moritz Hardt, and Arvind Narayanan • Artificial Intelligence: A Guide for Thinking Humans by Melanie Mitchell • Ethics of Artificial Intelligence and Robotics by Vincent C. Müller • Trustworthy AI: A Business Guide for Navigating Trust and Ethics in AI by Beena Ammanath.

1	**Code of the subject**	EE402
2	**Title of the subject**	Intelligent Transportation Systems

3	**Any prerequisite**	NA
4	**L-T-P**	**3-0-0**
5	**Learning Objectives**	To equip students with the knowledge to design, implement, and optimize advanced transportation technologies.
6	**Brief Contents**	Intelligent Transportation Systems covers the application of advanced technologies to improve transportation networks. It includes topics such as traffic flow analysis, vehicle detection systems, and real-time traffic management. The course explores the integration of communication technologies, such as V2X (Vehicle-to-Everything), for enhanced safety and efficiency. Additionally, it covers autonomous vehicles, smart traffic signals, and the role of data analytics in optimizing transportation systems. Students will study the development and implementation of smart transportation infrastructure, exploring issues related to system interoperability, communication standards, and system design.
7	**Contents for lab**	NA
8	**List of textbooks/references**	• Intelligent Transportation Systems: Smart and Green Infrastructure Design by S. S. M. Zubir • Intelligent Transportation Systems: Theory and Practice by Asim A. K. • Handbook of Intelligent Vehicles by Azim Eskandarian • Smart Transport Networks: Optimizing Performance and Efficiency by Richard E. D. and Ehsan N

1	**Code of the subject**	EE403
2	**Title of the subject**	Power Electronics
3	**Any prerequisite**	NA
4	**L-T-P**	3-0-2
5	**Learning Objectives**	• To familiarize students with various Power Electronic devices and their specifications. • To prepare the students to analyse and design different power converter circuits. • Acquire knowledge about fundamental concepts and techniques used in power electronics. • Ability to analyse various single phase and three phase power converter circuits and understand their applications.

6	**Brief Contents**	Power Semiconductor Devices: Diode, BJT, MOSFET, SCR, Triac, GTO, IGBT, MCT and their V-I characteristics, ratings, driver circuits, protection and cooling; AC-DC Converters (Rectifiers): Diode rectifier, thyristor based rectifier, effect of source inductance, single/three phase rectifiers, semi/full rectifiers, power factor, harmonics; DC-AC Converters (Inverters): Concept of switched mode inverters, PWM switching, voltage and frequency control of single/ three phase inverters, harmonics reduction, other switching schemes - square wave pulse switching, programmed harmonic elimination switching, current regulated modulation switching - tolerance band control, fixed frequency control; voltage source inverter (VSI), current source inverter (CSI); DC-DC Converters (Chopper): Principle; buck, boost and buck-boost converters; AC Voltage Controllers: Principle of ON-OFF control and phase control, single/three phase controllers, PWM AC voltage controller, cycloconverters;
7	**Contents for lab**	Study of Characteristics of SCR, MOSFET & IGBT, Single Phase Half controlled converter with R load, Single Phase fully controlled bridge converter with R and RL loads, Three Phase half controlled bridge converter with R load, Single Phase AC Voltage Controller with R and RL Loads, Single Phase Cyclo converters with R and RL loads, Single Phase series inverter with R and RL loads, DC Jones chopper with R and RL Loads
8	**List of textbooks/references**	• Power Electronics- Converters, Applications and Design by N. Mohan, John Wiley & Sons. • Introduction to Modern Power Electronics by Andrzej M. Trzynadlowski, John Wiley & Sons. • Power Electronics Circuits, Devices and Applications by M.H. Rashid, PHI.

1	**Code of the subject**	EE404
2	**Title of the subject**	IC Technology
3	**Any prerequisite**	NA
4	**L-T-P**	3-0-0
5	**Learning Objectives**	Students will be able to learn: • Fundamental principles of fabrication of VLSI devices. • Understand the IC Design flow from HDL to Layout. • Basic understanding of Physical design • Understand the IC Design from ASIC flow.
6	**Brief Contents**	Historical perspective, processing overview, Silicon Wafers, Thermal Oxidation, Lithography, Wet and Dry Etching, deposition technique, Diffusion, Ion Implantation CMOS Technology, Reliability, Yield, Challenges for integration, system on chip. IC design flow, RTL modelling, logic synthesis, formal verification, static timing analysis, timing-driven and power-driven optimization

		Physical Design, Partitioning, Floor planning, Power Planning, Placement, Clock Distribution Networks IC Design using the ASIC, Parasitic effects on circuit performance in Pre-layout and post-layout simulation, IO padding and packaging.
7	**Contents for lab**	NA
8	**List of textbooks/references**	• Fundamentals of Semiconductor Fabrication by G. S. May and S. M. Sze, Wiley. • Silicon VLSI Technology, Fundamentals, Practice and Modeling by J. D. Plummer, M. D. Deal and P. B. Griffin, Pearson education. • VLSI Technology by S. M. Sze, TMH. • Semiconductor Devices: Physics and Technology by S. M. Sze, Wiley. • Synthesis and Optimization of Digital Circuits by Giovanni De Micheli, Tata McGraw Hill. • High Level Synthesis: Introduction to Chip and System Design by D.D Gajski et al., Kluwer Academic Publishers. • Introduction to VLSI Design Flow by Sneh Saurabh, Cambridge University Press.

1	**Code of the subject**	EE498
2	**Title of the subject**	Colloquium (Based on industrial training)/ MOOC
3	**Prerequisite**	NA
4	**L-T-P**	0-0-6
5	**Learning Objectives**	• To instill the ability to identify skills and gain practical work experience • To provide an opportunity to observe and contribute in the workplace • To take ownership and responsibility of a project assignment, given by a designated manager/supervisor • To provide networking opportunities with other members of the organization • To offer performance feedback and mentorship throughout the internship
6	**Brief Contents**	An internship helps you train under experienced professionals and explore what your chosen career path would be like, and an internship with a company in your field can help you to develop the skills you require to thrive within a professional setting. At the end of the training period, the company may ask you to review your time with them and write a report based on your experience. In addition, hone the skills needed to develop internship report.
7	**Contents for lab**	There are no specific laboratory sessions for this. However, this being a completely practical-oriented course, the student has to devote significant time to achieve the objectives.

8	**Text /references**	1. https://www.careereducation.columbia.edu/resources/10-tips-make-most-internship 2. https://in.indeed.com/career-advice/career-development/internship-report

1	**Code of the subject**	EE499
2	**Title of the subject**	BTech Project/ Internship
3	**Any prerequisite**	
4	**L-T-P**	0-0-24
5	**Learning Objectives**	To develop deeper knowledge, understanding, capabilities and attitudes in the context of the programme of study.
6	**Brief Contents**	The purpose of this course is to enable the student to develop deeper knowledge, understanding, capabilities and attitudes in the context of the programme of study. The student is expected to demonstrate the abilities of the major subject/field of study, including deeper insight into hardware/software application development work. Develop the capability to create, analyse and critically evaluate different technical/architectural solutions. Equipped with the needed skills to clearly present and discuss the conclusions as well as the knowledge and arguments that form the basis for the learning outcome in written and spoken English. Importantly, it is necessary to march on the ethical aspects of research and development work.
7	**Contents for lab**	There are no specific laboratory sessions for this. However, this being a completely practical oriented course, the student has to devote significant time to achieve the objectives.
8	**List of textbooks/references**	https://grad.wisc.edu/wp-content/uploads/sites/329/2018/02/2018-Project-Management-for-Graduate-Students-Course-Workbook.pdf

1	**Code of the subject**	EE001
2	**Title of the subject**	VLSI Architecture
3	**Any prerequisite**	EE205, EE302
4	**L-T-P**	3-0-0
5	**Learning Objectives**	The course objective is to cover the architecture design of VLSI systems and subsystems with the notion of optimization for area, speed, power dissipation, cost and reliability. Different aspects of VLSI system design and its applications in various fields. The course also discusses traditional and state of the art analog and digital VLSI architectures optimized techniques.

6	**Brief Contents**	ISA, Datapath and control path design, Single Cycle MIPS , 5 Stage pipeline MIPS, CISC Architecture, RISC architecture, Arithmetic unit design, Fixed point and floating point, memory units, Optimization, Instruction level parallelism, Super scalar processor, multi-core and multi thread Architecture, Network on chip, Dynamically reconfigurable gate array, Static vs dynamic reconfiguration, single context vs multi-context dynamic reconfiguration, full vs partial runtime reconfiguration.
7	**Contents for lab**	NA
8	**List of textbooks/references**	• Digital Integrated Circuit Design: From VLSI Architectures to CMOS Fabrication by Hubert Kaeslin, Cambridge University Press. • Synthesis and Optimization of Digital Circuits by Giovanni De Micheli, McGraw Hill. • VLSI Array Processors by S.Y. Kung, Prentice Hall. • VLSI Design Methodologies for Digital Signal Processing Architectures by Magdy A. Bayoumi, Springer.

1	**Code of the subject**	EE002
2	**Title of the subject**	Quantum Electronics
3	**Any prerequisite**	EE203, EE204
4	**L-T-P**	3-0-0
5	**Learning Objectives**	The course gives an introduction to solid state physics and will enable the student to employ classical, and quantum mechanical theories needed to understand the physical properties of solids. Emphasis is put on building models able to explain several different phenomena in the solid state.
6	**Brief Contents**	The crystal structure of solids, Introduction to quantum mechanics: Principles of Quantum mechanics, Application of Schrodinger's Wave Equations, Introduction to Quantum Theory of Solids: The kronig-Penney Model, Electrical conduction in Solids, DOS, Statistical Mechanics, The semiconductor in Equilibrium Carrier transport Phenomenon, Non-equilibrium Excess Carriers in Semiconductor, PN-Junction, MOSCAP, Thin film Transistors, QCA
7	**Contents for lab**	NA
8	**List of textbooks/references**	• Semiconductor physics and devices: basic principles by Neamen, Donald A., McGraw-hill. • Fundamentals of modern VLSI devices by Taur, Yuan, and Tak H. Ning, Cambridge university press. • Quantum nano-electronics: An Introduction to Electronic Nanotechnology and Quantum Computing by Edward L. Wolf • Quantum Electronics by Amnon Yariv • Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience by Edward L. Wolf

1	**Code of the subject**	EE003
2	**Title of the subject**	Introduction to MEMS
3	**Any prerequisite**	EE304
4	**L-T-P**	3-0-0
5	**Learning Objectives**	After completion of the course student will be able to: • Understand the Basic concept of MEMS Fabrication Technologies, Piezoresistance Effect, Piezoelectricity, Piezoresistive Sensor. • Explain Mechanics of Beam and Diaphragm Structures. • Understand the Basic concept of Air Damping and Basic Equations for Slide-film Air Damping, Couette-flow Model, Stokes-flow Model. • Know the concept of Electrostatic Actuation. • Understand the applications of MEMS in RF
6	**Brief Contents**	Historical Background, Silicon Pressure sensors, Micromachining, Micro Electro-Mechanical Systems, Microfabrication and Micromachining: Integrated Circuit Processes, Bulk Micromachining, Physical Microsensors, Sensor Principles and Examples, Microactuators, Microactuator systems, Surface Micromachining, Surface Micro-machined Systems, Application Areas: All-mechanical miniature devices, 3-D electromagnetic actuators and sensors, RF/Electronics devices, Optical/Photonic devices, Medical device e.g. DNA-chip, micro-arrays.
7	**Contents for lab**	NA
8	**List of textbooks/references**	• Foundations of MEMS by C. Liu, Pearson/PH. • Essentials of Mechatronics by J. Billingsley, Wiley. • Mechatronics by S. Cetinkunt, Wiley. • RF MEMS: Theory, Design, and Technology by G. M. Rebeiz, Wiley. • Mechatronics System Design by D. Shetty and R. Kolk, Thomson. • Robot Modeling and Control by M. W. Spong, S. Hutchinson and M. Vidyasagar, Wiley.

1	**Code of the subject**	EE004
2	**Title of the subject**	VLSI Signal Processing
3	**Any prerequisite**	EE201, EE205
4	**L-T-P**	3-0-0
5	**Learning Objectives**	This course aims at providing comprehensive coverage of the important techniques for designing efficient VLSI architectures for DSP. This course will enable students to understand industrial challenges in the implementation of DSP systems, like capability to process high throughput data in real-time, as well as requiring less power and less chip area.
6	**Brief Contents**	Graphical representation of DSP algorithms, signal flow graph (SFG), data flow graph (DFG) and dependence graph (DG), high-

		level transformation, critical path, Retiming of DFG, critical path minimization by retiming, loop retiming and iteration bound, Cutset retiming, design of pipelined DSP architectures. Parallel realization of DSP algorithms, unfolding theorem, polyphase decomposition, hardware efficient parallel realization of FIR filters, 2-parallel and 3-parallel filter architectures, Hardware minimization by folding, delay optimization by folding, lifetime analysis. Pipelining digital filters, combining parallel processing with pipelining in digital filters.
7	**Contents for lab**	NA
8	**List of textbooks/references**	• VLSI Digital Signal Processing Systems by Keshab K. Parhi, Wiley Eastern. • Digital Signal Processing for Multimedia Systems by Keshab K. Parhi, Takao Nishitani, and Marcel Dekker. • Pipelined Lattice and Wave Digital Recursive Filters by J. G. Chung and Keshab K. Parhi, Kluwer. • VLSI Digital Signal Processing Systems: Design and Implementation by Parhi, K.K., John Wiley. • Discrete-Time Signal Processing by Parhi, K.K., Prentice Hall.

1	**Code of the subject**	EE005
2	**Title of the subject**	FPGA-based System Design
3	**Any prerequisite**	EE205
4	**L-T-P**	3-0-0
5	**Learning Objectives**	The goal of the course is to study the basic principles and methods of FPGA prototyping. Understanding of principles of IC prototyping; hardware and software; design strategies and methods
6	**Brief Contents**	ROM, SPLD, CPLD Architecture and Features of FPGA and designing techniques, Architecture of ROM, Programming, Architecture of SPLDs, SPLDs programming, Architecture of CPLDs, Basics of FPGAs, Structure of FPGAs, Implementation of Digital circuits in FPGA processor, Education FPGA kit, FPGA pin assignment, Interfacing Input/Output devices with FPGA, SPI, I2C, I3C, UART protocol RTL design, System Design Examples using Xillinx FPGAs, Traffic light Controller, Real Time Clock, VGA, Keyboard, LCD, Embedded Processor Hardware Design
7	**Contents for lab**	NA
8	**List of textbooks/references**	• Application Specific Integrated Circuits by M. J. S. Smith, Pearson. • Digital Design using VHDL by Peter Ashenden, Elsevier. • Digital Design using Verilog by Peter Ashenden, Elsevier. • FPGA based system design by W. Wolf, Pearson. • The Design Warriors's Guide to FPGAs by Clive Maxfield, Elsevier.

		• Verilog HDL: A Guide to Digital Design and Synthesis by Samir Palnitkar, Prentice Hall. • Digital VLSI System Design: A Design Manual for implementation of Projects on FPGAs and ASICs Using Verilog by S. Ramachandran, Springer Publication. • Wayne Wolf, "FPGA Based System Design", Prentices Hall Modern Semiconductor Design Series. • Digital Logic Design with Verilog HDL by Stephen Brown & ZvonkoVranesic, TATA McGraw Hill Ltd.

1	**Code of the subject**	EE006
2	**Title of the subject**	Design Verification and Testing
3	**Any prerequisite**	EE205
4	**L-T-P**	3-0-0
5	**Learning Objectives**	The main objective of this course is to provide in-depth understanding of the problems encountered in testing large circuits, approaches to detect and diagnose the faults and methods to improve the design to make it testable. The students will be able to develop algorithms and tools for VLSI testing, designing of testable and trustworthy circuits. The scope of this course is to particularly address the challenges in the VLSI testing domain and get motivated towards research in this field.
6	**Brief Contents**	Introduction and Fault Modeling, Testing Techniques, Time frame expansion methods, Boolean Satisfiability, transitive-closure based and Neural Network based approaches, Fault Simulation, Design for Testability and Built-in-self-test, Controllability and observability measures, TEMEAS, SCOAP, ad-hoc design built-in-logic-block-observer (BILBO), linear feedback shift register (LFSR), theory of LFSRs, Design for Trust Techniques: Different Types of Attacks, Counter Measures for different types of attacks, Prevention based Approaches, Importance of verification, Verification plan, Verification flow, Levels of verification, Verification methods and languages, Introduction to Hardware Verification methodologies, Verifications based on simulation, analytical and formal approaches. Functional verification, Timing verification, Formal verification. Basics of equivalence checking and model checking.
7	**Contents for lab**	NA
8	**List of textbooks/references**	• Essential of Electronic Testing for Digital, Memory, and Mixed Signal VLSI Circuits by M. L. Bushnell and V.D Agrawal, Springer. • VLSI Test Principles and Architectures by L.W. Wang, C.W. Wu, W. Xioqing, Academic Press. • Hardware Design Verification by William Lam, Prentice Hall, • Logics in Computer Science by M. Huth and M. Ryan, Cambridge University Press. • Introduction to Formal Hardware Verification by Thomas Kropf, Springer.

1	**Code of the subject**	EE007
2	**Title of the subject**	Device and Interconnect Modelling
3	**Any prerequisite**	EE205
4	**L-T-P**	3-0-0
5	**Learning Objectives**	Upon the completion of this course, the students are able to: • Concept of MOS modeling • Understand the advanced interconnect materials. • Acquire knowledge about Technology trends, Device and interconnect scaling. • Identify basic device and Interconnect Models. • Perform RLC based Interconnect analysis. • Analyse the problem with existing material in deep submicron.
6	**Brief Contents**	Technology trends, Device and interconnect scaling, Interconnect Models: RC model and RLC model, Effect of capacitive coupling, Effect of inductive coupling, Transmission line model, Power dissipation, Interconnect reliability, Driver and Load Device Models, Interconnect Analysis, Time domain analysis, RLC network analysis, RC network analysis and responses in time domain, S domain analysis, circuit reduction via matrix approximation, Analysis using moment matching, Crosstalk Analysis, Advanced Interconnect Materials. Introduction to the TCAD Simulation Tool, Examples of TCAD Simulations, Moore law, Technology nodes and ITRS, Physical & Technological Challenges to scaling, Two terminal MOS Device threshold voltage modelling, C-V Characteristics, Four terminal MOSFET threshold voltage I-V modelling, short channel effect (SCE), High-K gate dielectric, Nonconventional MOSFET – (FDSOI, SOI, Multi-gate MOSFETs). Nonconventional MOSFET – (FDSOI, SOI, Multi-gate MOSFETs).
7	**Contents for lab**	NA
8	**List of textbooks/references**	• Interconnect Analysis and Synthesis by Chung-Kang Cheng, John Lillis, Shen Lin and Norman H.Chang, A Wiley Interscience Publication. • CMOS Digital integrated circuits analysis and design by Sung-Mo (Steve) Kang, Yusuf Leblebigi, Tata Mcgraw-Hill. • Electronic properties of Carbon Nanotubes by Mauricio Marulanda, InTech publisher. • Computational Electronics: Semiclassical and Quantum Device Modeling and Simulation by Dr Vagica Vasileska and Stephen M. Goodnick. • Silicon Nanoelectronics by Shundri Oda & David Ferry, CRC Press.

1	**Code of the subject**	EE008

2	**Title of the subject**	CAD for VLSI
3	**Any prerequisite**	EE205
4	**L-T-P**	3-0-0
5	**Learning Objectives**	The main objective of this course is to provide in-depth understanding of the theoretical as well as practical concepts of the designing algorithms for CAD tools for VLSI design. The students will be able to identify and develop new algorithms and CAD tools for VLSI design. The scope of this course is also to visualize new Design Automation (DA) research problems in view of the challenges of designing multi-core and/or many-core system-on-chip in the nanometer regime. Another objective of this course is to give the exposure to machine learning and deep learning algorithms for designing efficient hardware in IOT era.
6	**Brief Contents**	Introduction to VLSI-CAD, module generation, PLAs and FPGAs, Digital hardware modeling, benchmark circuits (ISCAS'85, ISCAS'89…), Simulation algorithms design verification, graph data structure and algorithms for VLSI-CAD, High-level synthesis, Algorithms for physical design automation, slicing and non-slicing floorplans, polar graphs and adjacency graphs for floorplans, Introducing NOC as a future SOC paradigm, Timing analysis, SDC, set-up & hold time concept, timing exceptions, set-up & hold calculations, noise analysis.
7	**Contents for lab**	NA
8	**List of textbooks/references**	• Synthesis and Optimization of Digital Circuits by Giovanni DeMicheli, Tata McGraw-Hill. • High Level Synthesis: Introduction to Chip and System Design by D.D. Gajski et al., Kluwer Academic Publishers. • Computer Arithmetic: Algorithms and Hardware Designs by B. Parhami, Oxford Univ. Press. • VLSI physical design automation: theory and practice by S.M. Sait and H. Youssef, World Scientific Pub.Co.

1	**Code of the subject**	EE009
2	**Title of the subject**	Memory Devices and Circuits
3	**Any prerequisite**	EE205
4	**L-T-P**	3-0-0
5	**Learning Objectives**	The objective of the Memory Design is to acquaint the students with memory cell, memory peripherals, novel SRAM cell, next-generation memory. The subject gives the platform to analyze the read/write/hold operations of different memory structures using CAD tools.
6	**Brief Contents**	Overview of volatile memory, non-volatile memory, on-chip memory, on-chip memory types. Review of CMOS circuit design, sensing circuitry basics, read/write assist circuitry and other peripheral circuitries, next-generation SRAM cell, Introduction to DRAM, high-speed DRAM architectures, open and folded arrays organizations, bandwidth, latency, and cycle

		time, power, timing circuits, STT-MRAM, data migration policy for hybrid cache, Operation of FLASH memories (FLASH arrays sensing and programming), Charge Pump circuits. Basic of memory compiler for SRAM architecture using scripting language
7	**Contents for lab**	NA
8	**List of textbooks/references**	• VLSI Memory Chip Design by KiyooItoh, Springer. • Ultra-low Voltage Nano-scale Memories by KiyooItoh, Masashi Horiguchi, Hitoshi Tanaka, Springer. • Semiconductor Memories: Technology, Testing, and Reliability by Ashok K. Sharma, Wiley IEE. • Semiconductor Memories: A Handbook of Design, Manufacture and Application by Betty Prince, Wiley. • DRAM Circuit Design: Fundamentals and High-Speed Topics by Keeth, Baker, Johnson, and Lin, Wiley.

1	**Code of the subject**	EE010
2	**Title of the subject**	Embedded Software
3	**Any prerequisite**	EE306
4	**L-T-P**	3-0-0
5	**Learning Objectives**	Analyze and explain the control-flow and data-flow of a software program and a cycle-based hardware description. Transform simple software programs into cycle-based hardware descriptions with equivalent behavior and vice versa. Partition simple software programs into hardware and software components and create appropriate hardware-software interfaces to reflect this partitioning. Identify performance bottlenecks in a given hardware-software architecture and optimize them by transformations on hardware and software components.
6	**Brief Contents**	Design of embedded systems, Architectures and platforms for embedded systems, General purpose vs. application specific architectures, Reconfigurable Systems, Modeling techniques, Models of computations, Synchronous finite state machines, Time and synchrony, Co-design finite state machines, System design with the POLIS system, Performance analysis and co-simulation, Static analysis techniques, Co-simulation of heterogeneous systems with Ptolemy, Optimization techniques for design space exploration, Software synthesis and code generation, Retargetable compilers, System-level power/energy optimization Mapping and scheduling for low energy, Real-time scheduling with dynamic voltage scaling.
7	**Contents for lab**	NA

8	**List of textbooks/references**	• System-Level Synthesis, Ahmed A. Jerraya, Jean Mermet, Kluwer Academic Publishers. • Hardware-Software Co-design of Embedded Systems. The POLIS Approach", Felice Balarin, Kluwer Academic Publishers.

1	**Code of the subject**	EE011
2	**Title of the subject**	Organic Semiconductors
3	**Any prerequisite**	EE203
4	**L-T-P**	3-0-0
5	**Learning Objectives**	• Understand the fundamentals of organic semiconductors • To have knowledge about Optical and Electrical Properties of Organic Semiconductor Material • Understand and design organic electronic devices • Explore current research and emerging technologies in organic devices
6	**Brief Contents**	General Overview of Organic Semiconductors Devices; Electronic Transitions, Excitons, and Energy transfer; Charge generation and recombination mechanisms; Polaron and Disorder models for charge transport; Space charge and Trap limited currents; Charge injection at metal/organic interface; Organic Thin Film Transistor (OTFT) physics and processing; Organic Light Emitting Diode (OLED) physics and processing; OLED passive and active matrix displays, OTFT circuits; Organic Solar Cell physics and processing; Research opportunities in organic electronics and the associated technologies. Labs: Fabrication of an organic device and its characterization.
7	**List of textbooks/ references**	• Physics of Organic Semiconductors, Wolfgang Brütting and Chihaya Adachi, Wiley-VCH. • Electronics Processes in Organic Semiconductors - An Introduction,Anna Köhler and Heinz Bässler, Wiley-VCH.

1	**Code of the subject**	EE012
2	**Title of the subject**	Solar Cells-Fundamental & Applications
3	**Any prerequisite**	EE203
4	**L-T-P**	3-0-0
5	**Learning Objectives**	• Understand the fundamental principles of Solar Cell and photovoltaic energy. • Analyze performance losses and strategies for improvement • Understand advanced and emerging solar cell technologies

6	**Brief Contents**	Solar Cell Technologies Crystalline Cells: Mono-crystalline and polycrystalline cells; Solar grade Silicon, Si usage in solar PV; Commercial Si solar cells, process flow of commercial Si cell technology; Sawing and surface texturing, diffusion process, thin film layers, Metal contact; Sources of Losses and prevention, Common Features: Substrate and Super-state configuration; Thin film module manufacturing, Amorphous Si Solar cell technology, Cadmium Telluride Cell; CIGS solar Cell; Cooling requirements, High concentration solar cells, Emerging technologies in Solar Cells-Fundamental & Applications
7	**List of textbooks/ references**	• Solar Electricity Handbook, Michael Boxwell, Greenstream publishing ltd • Fundamentals of Renewable Energy Systems, D. Mukherjee, New Age

1	**Code of the subject**	EE013
2	**Title of the subject**	Energy Storage Materials
3	**Any prerequisite**	EE203
4	**L-T-P**	3-0-0
5	**Learning Objectives**	• Understand the storage of energy in a society with increasing use of renewable energy sources • Analyze the basic operating principles for modern energy production and energy storage technologies • Understand the advantages and disadvantages of different energy storage mechanisms
6	**Brief Contents**	Introduction to studies in battery technology and energy storage; Energy production & storage of sustainable societies and renewable energy; Basic function and configuration of electrochemical cells for energy storage such as batteries (primary and secondary), fuel cells, and supercapacitors; Li-ion batteries; function of anodes, cathodes, electrolytes; Charging Optimization Methods for Lithium-Ion Batteries; Thermal run-away for battery systems, Emerging technologies in Energy Storage Materials
7	**List of textbooks/ references**	• Energy Storage: Fundamentals, Materials and Applications, Rober Huggins, Springer • Behaviour of Lithium-Ion Batteries in Electric Vehicles: Battery Health, Performance, Safety, and Cost, Pistoia, Gianfranco, and Boryann Liaw, Springer International Publishing AG.

1	**Code of the subject**	EE014
2	**Title of the subject**	Communication Networks and Switching
3	**Any prerequisite**	EE303

4	**L-T-P**	3-0-0
5	**Learning Objectives**	• To provide a foundational view of layered communication architectures (OSI and TCP/IP). • Understand the client/server model and key application of layer protocols. • To provide the concepts of reliable data transfer and how TCP implements these concepts. • To appraise the knowledge of the student with current topics; security, network management, sensor networks, and/or other topics.
6	**Brief Contents**	Introduction to layered network architecture, protocol layers, and their service models (OSI and Internet protocol); Link Layer protocols, high-speed packet switching, queueing theory, routing; Internet Protocol; reliability, flow control, congestion control, and their embodiment in TCP; quality of service; and network security, Local Area Networks, and Wide Area Networking issues including routing and flow control; Fundamentals of SDN and IoT Implementation of Network topologies, error detection and correction methods, to connect two pc's using peer-to-peer communication, Implementation of a small network using a hub and switch, Network Socket Programming
7	**Contents for lab**	NA
8	**List of textbooks/references**	• Computer Networking: A Top-Down Approach, by J. F. Kurose and K. W. Ross, Addison Wesley. • Data and Computer Communications, W. Stallings • Computer Networks and Internets, D. E. Comer and R. E. Droms • Data Networks by R. Gallager and D. P. Bertsekas, Prentice-Hall.

1	**Code of the subject**	EE015
2	**Title of the subject**	Information Theory and Coding
3	**Any prerequisite**	ES102, ES103
4	**L-T-P**	3-0-0
5	**Learning Objectives**	• Understand and appreciate how information theory is concerned with the fundamental limits of communication. • Understand the application of Information Theory to Source Coding and Data Compression • Understand the concept of channel coding and error correction techniques
6	**Brief Contents**	Mutual information, entropy for discrete ensembles, Shannon`s noiseless coding theorem, Encoding of discrete sources. Markov sources, Shannon`s noisy coding theorem and converse for discrete channels, Calculation of channel capacity and bounds for discrete channels, Application to continuous channels. Techniques of coding and decoding, Huffman codes and uniquely detectable codes, Cyclic codes, convolutional arithmetic codes, Combinatorial Designs, Network Coding.

7	**Contents for lab**	NA
8	**List of textbooks/references**	• Information and Coding by N. Abramson, McGraw Hill. • Introduction to Information Theory by M. Mansurpur, McGraw Hill. • Elements of information theory by J. A. Thomas and T. M. Cover, Wiley. • Network Coding– Fundamentals and Applications by M. Medard and A. Sprintson, Acadamic Press. • The theory of information and coding by R. J. McEliece, Cambridge • Error Control Coding by Shu Lin and Daniel J. Costello, Prentice Hall.

1	**Code of the subject**	EE016
2	**Title of the subject**	High-Performance Computing
3	**Any prerequisite**	EE401
4	**L-T-P**	3-0-0
5	**Learning Objectives**	• Understand and appreciate how information theory is concerned with the fundamental limits of communication. • Understand the application of Information Theory to Source Coding and Data Compression • Understand the concept of channel coding and error correction techniques
6	**Brief Contents**	Parallel Processing Concepts, Levels of parallelism, Models (SIMD, MIMD, SIMT, SPMD, Dataflow Models, Demand-driven Computation etc), N-wide superscalar architectures, multi-core, multi-threaded, Parallel Programming with CUDA: Processor Architecture, Interconnect, Communication, Memory Organization, and Programming Models in high-performance computing architectures: (Examples: IBM CELL BE, Nvidia Tesla GPU, Intel Larrabee Microarchitecture and Intel Nehalem microarchitecture), Memory hierarchy and transaction-specific memory design, Thread Organization Fundamental Design Issues in Parallel Computing, Fundamental Limitations Facing Parallel Computing, Power-Aware Computing and Communication, Advanced Topics: Petascale Computing, Optics in Parallel Computing, Quantum Computers, Recent developments in Nanotechnology and its impact on HPC
7	**Contents for lab**	NA
8	**List of textbooks/references**	• Highly Parallel Computing by George S. Almasi and Alan Gottlieb • Advanced Computer Architecture: Parallelism, Scalability, Programmability by Kai Hwang, McGraw Hill.

		• Parallel Computer Architecture: A hardware/Software Approach by David Culler Jaswinder Pal Singh, Morgan Kaufmann. • Scalable Parallel Computing by Kai Hwang, McGraw Hill. • Principles and Practices on Interconnection Networks by William James Dally and Brian Towles, Morgan Kauffman. • GPU Gems 3 by Hubert Nguyen (Chapter 29 to Chapter 41) • Introduction to Parallel Computing by Ananth Grama, Anshul Gupta, George Karypis, and Vipin Kumar. • Petascale Computing: Algorithms and Applications by David A. Bader (Ed.), Chapman & Hall/CRC, Computational Science Series.

1	**Code of the subject**	EE017
2	**Title of the subject**	Biomedical Signal Processing
3	**Any prerequisite**	EE301
4	**L-T-P**	3-0-0
5	**Learning Objectives**	• Understand practical problems in objective analyses of biomedical signals. • Understand the theoretical background underlying the use of digital signal processing and statistical techniques for biomedical applications. • Identify the best solution for specific problems by considering the benefits and limitations of various digital signal processing approaches. • Implement appropriate signal processing algorithms for practical biomedical applications.
6	**Brief Contents**	Overview of biomedical signals such as ECG, EEG, MEG, Ultrasound; Fourier transforms review and filter design, Random and Structured Noise, Physiological Interference, Stationary and Nonstationary Processes, Noises and Artifacts Present in ECG, Time and Frequency Domain Filtering statistical inference on signals and images; EEG Signal Processing and Event Detection in Biomedical Signals, estimation theory with application to inverse imaging and system identification; spectra, spectrograms and wavelet analyses; pattern classification and diagnostic decisions, Analysis of Nonstationary Signals.
7	**Contents for lab**	NA
8	**List of textbooks/references**	• Biomedical Signal Processing: Principles and Techniques by D.C. Reddy, Tata McGrawHill Education. • Biomedical signal analysis by Rangayyan, R.M., John Wiley & Sons.

		• Biomedical digital signal processing by Tompkins, W.J., Editorial Prentice Hall. • Bioelectrical signal processing in cardiac and neurological applications by Sörnmo, L. and Laguna, P., Academic Press.

1	**Code of the subject**	EE018
2	**Title of the subject**	Neuromorphic Computing
3	**Any prerequisite**	EE401
4	**L-T-P**	3-0-0
5	**Learning Objectives**	• Understand volatile/non-volatile memories in greater detail. • Electrical equivalent model of neuron • Basic understanding of Perceptron (Artificial Neural Network) • Emerging memory devices for the realization of dynamics of biological neuron and synapse
6	**Brief Contents**	Memory Organization and overview of memory technology: markets trends and technology, Volatile memory (SRAM and 1T/1C-DRAM), capacitorless DRAM Flash Memory: Pool Frenkel Emission and Fowler-Nordheim tunnelling, floating gate and charge-trap (O/N/O) gate, reliability and scaling, Embedded Flash memory technology: silicon and nanocrystals, engineered CT layers and Split-gate memory architecture. Neuronal dynamics: Overview biological neuron and synapse, Hodgkin-Huxley Model, Leaky Integrated Fire (LIF) and Integrated Fire (IF) model, Atkinson and Shiffrin stage model of memory storage, Artificial neural network (ANN) and Spiking Neural Network (SNN). Realization of artificial neuron and synapse using two terminal devices and MOS transistors, Hardware accelerators.
7	**Contents for lab**	NA
8	**List of textbooks/references**	• Advances in non-volatile memory and storage technology by Y. Nishi and Magyari-Kope, Woodhead Publishing. • Neuromorphic Computing and Beyond: Parallel, Approximation, Near Memory, and Quantum by Khaled Salah Mohamed. • Neuromorphic Devices for Brain-inspired Computing: Artificial Intelligence, Perception, and Robotics by Qing Wan, and Yi Shi.

1	**Code of the subject**	EE019
2	**Title of the subject**	Advance Signal Processing
3	**Any prerequisite**	EE301
4	**L-T-P**	3-0-0

5	**Learning Objectives**	• Analyse and synthesise multirate DSP systems. • Understanding filter banks and wavelets for industrial applications. • Estimation of parameters to take a wavelet transform, and interpret and process the result. • Have an in-depth knowledge of use of digital systems in real time applications • Apply the algorithms for wide area of recent applications.
6	**Brief Contents**	Review of DFT, z-transform, and digital filters, Decimation and interpolation, Filters in sampling rate alteration systems, Polyphase decomposition and efficient structures, and filter banks. STFT, Wavelet theory, Spectral estimation, Periodogram, Bartlett's method, Welch's method, and ARMA modelling. Adaptive signal processing, Wiener Filter, Kalman Filter, LMS, and RLS.
7	**Contents for lab**	NA
8	**List of textbooks/references**	• Digital Signal Processing: Principles, Algorithms, and Applications by J. G. Proakis, D. G. Manolakis, Prentice Hall. • Digital Signal Processing: A Computer Based Approach by S. K. Mitra, McGraw Hill Higher Education. • Discrete-time signal processing by A. V. Oppenheim, R. W. Schafer, Prentice Hall. • Statistical Signal Processing and Modeling by M. H. Hayes, John Wiley and Sons.

1	**Code of the subject**	EE020
2	**Title of the subject**	Optical Communication
3	**Any prerequisite**	EE207
4	**L-T-P**	3-0-0
5	**Learning Objectives**	• Enrich the knowledge of the students to the basics of signal propagation through optical fibers, fiber impairments, components and devices. • Familiarize with the Design considerations of fiber optic systems
6	**Brief Contents**	Introduction to fiber optics, principles and motivation, Optical Sources : LED, Need for Laser Diodes, Resonator Concepts, Laser Diodes, Modulation response of LD, Chirp, Noise in Lasers, different modulation schemes, Optical Fibers, Photo detectors, Optical Link Design, Nonlinear effects, Coherent Detection and DSP, Optical Networks: SDH/SONET Layering, Frame Structure, Physical network topologies, Access Networks-PON, Optical Interconnects, Data Centers, Optical communication for Wireless Fronthauling
7	**Contents for lab**	NA

8	**List of textbooks/references**	• Fiber Optics Communication and Other Application by Henry Zanger and Cynthia Zanger, Macmillan Publishing Company, Singapore. • Optical Fiber Communication by G. Keiser, McGraw Hill. • Optical Fiber Communications by J. M. Senior, PHI.

1	**Code of the subject**	EE021
2	**Title of the subject**	Advanced Communication Engineering
3	**Any prerequisite**	EE207
4	**L-T-P**	3-0-0
5	**Learning Objectives**	• Analyze error performance of digital communication systems in the presence of additive noise. • Develop strong mathematical foundation and intuition to pursue any advanced topic in communications (wireless communication, detection and estimation theory, etc.) • Enriched understanding on recent communication technology viz., mm wave and THz Communication, IRS and UAV aided communication
6	**Brief Contents**	Introduction, Autocorrelation, Cross correlation, Energy Spectral Density (ESD) and Power Spectral Density (PSD), Optimum receivers for AWGN channels: Correlation and matched filter receivers, Fundamentals of detection: Maximum likelihood decoding etc, Coherent and noncoherent modulation, Digital communication through band-limited channels, Spread spectrum for digital communications, Multichannel communications with OFDM fundamentals. Introduction to wireless communication systems and wireless channels, Wireless channel models, MIMO channel model, Information Theory basics for MIMO communication, Capacity of MIMO Communication systems, Diversity performance of MIMO channels, Space Time Coding schemes, Multi-user MIMO communication, distributive MIMO, mm and THz communication: Characteristics, Standardization and Regulation, Radio Propagation at mm Waves, THz Propagation and Channel Modelling, THz Devices, Transceiver Technologies, Integrated Passive Components, Circuits and Interconnects, Modulation, radiating systems, mm Wave MIMO, Beam Steering and Beam Forming, IRS aided Communication, Cognitive radio, cooperative communication, Relay networks, free space optical (FSO) communication, UAV aided communication
7	**Contents for lab**	NA
8	**List of textbooks/references**	**Text/ Reference Books:** • Advanced Millimeter-wave Technologies Antennas, Packaging and Circuits by Duixian Liu, Brian Gaucher, Ulrich Pfeiffer and JanuszGrzyb, John Wiley & Sons Ltd, United Kingdom.

		• Millimeter wave communication systems by Kao-Cheng Huang, Zhaocheng Wang, John Wiley & Sons. • THz Communications by Thomas Kürner, Daniel M. Mittleman and Tadao Nagatsuma; Springer Series in Optical Sciences. • Microwave Engineering: Passive Circuits by P A Rizzi, PHI. • Foundations of Microwave Engineering by R E Collin, John Wiley and Sons India Pvt. Ltd. • High Frequency Integrated Circuits by Sorin Voinigescu, Cambridge University Press, UK.

1	**Code of the subject**	EE022
2	**Title of the subject**	Speech and Audio Signal Processing
3	**Any prerequisite**	EE301
4	**L-T-P**	3-0-0
5	**Learning Objectives**	After the completion of the course, the students will be able to: • Understand basic concepts of speech production, speech analysis, speech coding and parametric representation of speech and apply it in practical applications • Develop systems for various applications of speech processing. • Learn Signal processing models of sound perception and application of perception models in audio signal processing. • Implement audio compression algorithms and standards.
6	**Brief Contents**	Speech production, Time domain analysis, Frequency domain analysis, Cepstral analysis, LPC analysis, Speech coding, Speech recognition, Speech enhancement, Text to speech conversion. Signal Processing Models of Audio Perception, Psycho-acoustic analysis, Spatial Audio Perception and rendering, Audio compression methods, Parametric Coding of Multichannel audio, Transform coding of digital audio, audio quality analysis.
7	**Contents for lab**	NA
8	**List of textbooks/references**	• Speech Communications: Human & Machine by Douglas O'Shaughnessy, IEEE Press. • Speech and Audio Signal Processing: Processing and Perception Speech and Music by Nelson Morgan and Ben Gold, John Wiley & Sons. • Fundamentals of Speech Recognition by Rabiner and Juang, Prentice Hall. • Digital Processing of Speech Signals by Rabiner and Schafer, Prentice Hall. • Discrete-Time Speech Signal Processing: Principles and Practice by Thomas F. Quatieri, Prentice Hall.

1	**Code of the subject**	EE036

2	**Title of the subject**	Digital Communication
3	**Any prerequisite**	EE201
4	**L-T-P**	3-0-0
5	**Learning Objectives**	• Understand core concepts in digital communication systems. • Analyze system performance under ideal and non-ideal conditions. • Explore applications of digital communication in modern technologies.
6	**Brief Contents**	Introduction to Digital Communication, System Components and Applications, Signal Space Representation, Basis Functions, Orthogonality, Source Coding Techniques, Entropy, Lossless Compression Methods, Channel Capacity, Mutual Information, Source-Channel Separation, Pulse Shaping, Inter-Symbol Interference, Eye Diagrams, Matched Filtering, Optimal Receiver Design, SNR Maximization, Synchronization Techniques, Phase-Locked Loops, Timing Recovery, Trellis-Coded Modulation, Turbo Codes, LDPC Codes, Optical and Satellite Digital Communication Systems, Digital Media Transmission, Communication Security, Emerging Trends in Digital Communication.
7	**Contents for lab**	NA
8	**List of textbooks/references**	• Digital Communications – John G. Proakis, 5th Edition, McGraw-Hill, 2008 • Modern Digital and Analog Communication Systems – B.P. Lathi and Zhi Ding, 4th Edition, Oxford University Press, 2009 • Digital Communication: Fundamentals and Applications – Bernard Sklar and Pabitra Kumar Ray, 2nd Edition, Pearson Education, 2009 • Principles of Digital Communication – Robert G. Gallager, 1st Edition, Cambridge University Press, 2008 • Information Theory, Inference, and Learning Algorithms – David J.C. MacKay, 1st Edition, Cambridge University Press, 2003

1	**Code of the subject**	EE037
2	**Title of the subject**	Microwave Circuits Design
3	**Any prerequisite**	EE202, EE208
4	**L-T-P**	3-0-0
5	**Learning Objectives**	• Theoretical knowledge and design methods of RF and microwave circuits, especially passive components, and their implementation techniques. • Different types of transmission lines, their applications, and microwave network analysis. • Understanding and design of planar circuits, filters and couplers
6	**Brief Contents**	Transmission lines and parameters, concepts of propagation constant, characteristic impedance, reflection coefficient, wave velocities and dispersion, smith chart, impedance transformers,

		source and load mismatches, lossy transmission lines. S, Z, Y, ABCD, and other multi-port parameters, impedance matching. Microstrip, strip line, coplanar waveguide and other types of transmission lines, microstrip discontinuities, printed couplers, filters, power dividers, couplers and resonators
7	**Contents for lab**	• Design and Development of 50 Ohm Microstrip Transmission Line • Design and Development of Matching Network to Match complex load to 50 Ohm Source. • Design and Development of Branch Line Coupler. • Design and Development of Wilkinson Power Divider. • Design and Development of Band Pass filter.
8	**List of textbooks/references**	• D.M. Pozar, "Microwave Engineering (3rd edition)", Wiley-India. • Foundations for Microwave Engineering, Robert E Collin, McGraw-Hill. • Foundations of Microstrip Circuit Design, T. C. Edwards, John Wiley & Sons. • Lab Manual for Labs

1	**Code of the subject**	EE038
2	**Title of the subject**	RFIC Design
3	**Any prerequisite**	EE203
4	**L-T-P**	3-0-0
5	**Learning Objectives**	• Definition of RF Transceiver Architectures, FCC Regulations Wireless. • Basics understanding of Passive components and Devices and their high-frequency equivalent circuits. • Understanding and designing of RF Oscillators, Mixers, LNA and Power Amplifiers
6	**Brief Contents**	Passive and active components, matching networks, Diodes, Switches, and Phase Shifters. Noise, Nonlinearity. LNAs and power amplifiers (PAs): General classification and design techniques, large signal parameters. Passive and active mixers, down-conversion and up-conversion mixers, and topologies. The basic principle of oscillators, Voltage-Controlled Oscillators (VCOs), Frequency multipliers, Integer-and fractional-N synthesizers
7	**Contents for lab**	NA
8	**List of textbooks/references**	• John Rogers and Calvin Plett, "Radio Frequency Integrated Circuit Design" Artech House London. • Behzad Razavi, "RF Microelectronics" 2nd Ed, Pearson • Ulrich L. Rohde, Matthias Rudolph, "RF / Microwave Circuit Design for Wireless Applications," 2nd Edition, 2012. • D.M. Pozar, "Microwave Engineering (3rd edition)", Wiley-India, 2010 • http://www.ittc.ku.edu/~jstiles/622/handouts/

1	**Code of the subject**	EE023
2	**Title of the subject**	Sensors for Autonomous Systems
3	**Any prerequisite**	EE304
4	**L-T-P**	3-0-0
5	**Learning Objectives**	• Deeply understand the Fundamentals common to widely used sensing and filtering systems. • Select appropriate sensors and data acquisition hardware to instrument electro-mechanical equipment, with a full awareness of practical constraints and real-world problems. • Be able to use model based and state-based control to module systems, and carry out system analysis.
6	**Brief Contents**	Use of autonomous systems, Sensing, methods for data acquisition, issues associated with different techniques (e.g. Nyquist, noise, etc.), Control Strategies, modelling dynamic systems using transfer functions, model based control, stability of control systems, state space analysis, feedback control methods using observability and parameter estimation, Fuzzy control, digital control, rule based and optimisation approaches, Brute Force and enumeration, linear programming, genetic algorithms, graph based approaches, dynamic programming, simulated annealing, ant colony, Tabu search, other artificial intelligence approaches, Actuation and systems.
7	**Contents for lab**	NA
8	**List of textbooks/references**	• Introduction to Autonomous Mobile Robots by Illah R. Nourbaksh and Roland Siegwart, The MIT Press • State Estimation for Robotics by Timothy Barfoot, Cambridge: Cambridge University Press. • Sensing and Control for Autonomous Vehicles: Applications to Land, Water and Air Vehicles by Thor I. Fossen, Kristin Y. Pettersen, Henk Nijmeijer

1	**Code of the subject**	EE024
2	**Title of the subject**	Power Systems
3	**Any prerequisite**	EE403
4	**L-T-P**	3-0-0
5	**Learning Objectives**	• Understanding the basics of power system generation, transmission, distribution system. • Modeling, Design, and Evaluation of various parameters of transmission lines. • Understand power system stability and control. • Acquire knowledge of underground cables: construction, methods of laying, grading, and determination of fault location.
6	**Brief Contents**	Energy resources, power generation: Thermal, hydro and nuclear power plants. Transmission lines, line parameters,

		corona, interference of power lines with communication circuits, line insulators. Cables, per unit system, symmetrical components, fault analysis, switching surges. Integrated operation of power systems, basic concepts of load flow, economic operation, stability, protection, HVDC transmission. Load management and tariffs
7	**Contents for lab**	NA
8	**List of textbooks/references**	• Power System Engineering, D. Kothari, I. Nagrath, McGraw Hill Education • Power system analysis, John Grainger, W. D. Stevenson, McGraw Hill Education

1	**Code of the subject**	EE025
2	**Title of the subject**	Power Electronic Converters for Renewable Energy
3	**Any prerequisite**	EE403
4	**L-T-P**	3-0-0
5	**Learning Objectives**	• Able to analyze and enhance the knowledge of single and three phase AC voltage controllers. • Knowledge of renewable energy sources and their power convertors. • Understand the design and control power convertor of smart grids.
6	**Brief Contents**	Introduction: Potential of renewable energies in India's future Power generation, Need of power electronics for power generation from renewable energies; Single and three phase convertor; Solar PV Systems: Solar PV characteristics, Grid requirement for PV, Power electronic converters used for solar PV, Control techniques, battery charging in PV systems; Wind Energy Conversion: Wind Turbine characteristics, Grid requirement for Wind, Power electronic converters for PMSM and DFIG, Control techniques; Other renewable energy systems: Fuel Cells, Biogas, Biomass etc; Power electronic converters and control for Microgrids and Smart grids.
7	**Contents for lab**	NA
8	**List of textbooks/references**	• Grid Converters for Photovoltaic and Wind Power Systems by Remus Teodorescu, Marco Liserre, Pedro Rodriguez, Wiley-IEEE Press. • Power Electronic Converters for Microgrids by Suleiman M. Sharkh, Mohammad A. Abu-Sara, Georgios I. Orfanoudakis, Babar Hussain, Wiley-IEEE Press. • Advanced DC/AC Inverters: Applications in Renewable Energy Fang Lin Luo, Hong Ye, CRC Press. • Power Electronics for Renewable and Distributed Energy Systems by Sudipta Chakraborty, Marcelo G. Simões, William E. Kramer, Springer.

1	**Code of the subject**	EE026
2	**Title of the subject**	Smart Grid Technology
3	**Any prerequisite**	EE403
4	**L-T-P**	3-0-0
5	**Learning Objectives**	• To understand smart grid technologies and application of smart grid concept in hybrid electric vehicles etc. • To have knowledge on smart substations, feeder automation and application for monitoring and protection. • To have knowledge on micro grids and distributed energy systems. • To know power quality aspects in smart grid and to understand latest developments in ICT for smart grid. • Analyse micro grids and distributed generation systems.
6	**Brief Contents**	Evolution of Electric Grid, Concept of Smart Grid, Definitions, Need of Smart Grid, Functions of Smart Grid, Opportunities & Barriers of Smart Grid, Difference between conventional & smart grid, Concept of Resilient & Self-Healing Grid. Introduction to Smart Meters, Real Time pricing, Smart Appliances, AMR, OMS, PHEV, V2G, Smart Sensors, Home & Building Automation, Phase Shifting Transformers, Smart Substations, Substation Automation, Feeder Automation. GIS, Intelligent Electronic Devices & their application for monitoring & protection, Smart storage like Battery, SMES, Pumped Hydro, Compressed Air Energy Storage, WAMS, Phase Measurement Unit. Concept of micro grid, need & applications of micro grid, formation of micro grid, Issues of interconnection, protection & control of micro grid. Plastic & Organic solar cells, thin film solar cells, Variable speed wind generators, fuel cells, micro turbines, Captive power plants, Integration of renewable energy sources. Power Quality Management in Smart Grid.
7	**Contents for lab**	NA
8	**List of textbooks/references**	• The Smart Grid: Enabling Energy Efficiency and Demand Response by Clark W. Gellings, CRC Press. • Smart Grid: Technology and Applications by Janaka Ekanayake, Nick Jenkins, Kithsiri Liyanage, Jianzhong Wu, Akihiko Yokoyama, Wiley. • Microgrids and Active Distribution Networks by S. Chowdhury, S. P. Chowdhury, P. Crossley, Institution of Engineering and Technology. • Smart Grids (Power Engineering), Stuart Borlase, CRC Press. • The Advanced Smart Grid: Edge Power Driving Sustainability by Andres Carvallo, John Cooper, Artech House Publishers. • Communication and Networking in Smart Grids by Yang Xiao, CRC Press.

1	**Code of the subject**	EE027
2	**Title of the subject**	Electromechanics
3	**Any prerequisite**	EE403
4	**L-T-P**	3-0-0
5	**Learning Objectives**	• Analyze magnetic circuits. • Resolve three-phase circuit problems • Analyze single-phase and three-phase transformers. • Analyze dc motors and synchronous machines. • Analyze induction motors.
6	**Brief Contents**	Magnetic Circuits- Simple magnetic circuit, analogy between magnetic circuits and electrical circuits, hysteresis and eddy current losses; Transformers: Single Phase transformers, equivalent circuit, determination of transformer equivalent circuit parameters, Three Phase transformers, Special Multiphase Transformers.; Electro-Mechanical Conversion: Principle of conservation of energy, Force and torque in electro-mechanical systems; DC Machines: Principle of EMF and torque production, energy conversion through electromagnetic field, DC Generators types, DC Motors; Synchronous Machines: Synchronous Generators, voltage regulation, Characteristics, Synchronous motors; Induction Machines: working, cage and slip ring rotors, equivalent circuit, determination of circuit parameters, Induction Generators; Fractional kW Machines: Single phase induction motors, Reluctance motors, Hysteresis motors, Universal motors.
7	**Contents for lab**	NA
8	**List of textbooks/references**	• Electric Machinery by A. E. Fitzgerald, C. Kingsley, S. D. Umans, McGraw-Hill • Electromechanics: Principles, Concepts, and Devices by James H. Harter, Pearson

1	**Code of the subject**	EE028
2	**Title of the subject**	Drone Technology and Robotics
3	**Any prerequisite**	EE304
4	**L-T-P**	3-0-0
5	**Learning Objectives**	• To describe in detail how industrial robot systems are used, structured and operate, • describe in detail the structure and operation of robotic tooling, including actuators, mechanics and sensors. • describe other parts of automated manufacturing systems, including process control, component flows, machine safety and personal safety. • describe computer-aided production tools and data communication within an industrial robotics network. • identify fundamental issues within sustainable industrial development from an automation perspective and be able to exemplify the consequences of these.
6	**Brief Contents**	Introduction to Robotics: Basic definitions, mechanism, degree of freedom, classification and specifications of Robots,

		Industrial Robots, sensors, controller, actuator. Kinematics: Position and orientation of links, Coordinate transformation, d-h parameters, joint variable and position of end effectors, inverse kinematic analysis. Velocity analysis – Jacobian. Static force analysis. Trajectory generation. Determining the joint variables for desired trajectory generation. Manipulator Dynamics – Newtons laws, Eulers equation and Lagrange formulation. Linear and nonlinear control of manipulators, Computer-Aided Design and 3D Printing. Introduction to fixed-wing UAVs, Introduction to Design, Basic Design Parameters, Design Algorithm, Layout, Performance and Stability Analysis, Simulation, Detailed Sizing, Estimation of inertial properties using 3D modelling, Prototype Fabrication, Wind Tunnel Testing, Aerodynamic Characterization through Wind Tunnel Testing
7	**Contents for lab**	NA
8	**List of textbooks/references**	• Mark W. Spong, Seth Huchinson and M. Vidyasagar, "Robot Modeling and Control", John Wiley and Sons, Inc., 2005 • John J. Craig, "Introduction to Robotics: Mechanics & Control", 3rd Edition, Prentice Hall, 2004 • Richard Murray, A. Lee, S. Sastry, "A Mathematical Introduction to Robotic Manipulation", CRC Press, 1994 • Robert J Schilling, Fundamentals of Robotics, Prentice Hall India, 200 • John J Craig, Introduction to Robotics, Prentice Hall International, 2005 • Niku Saeed B., "Introduction to Robotics: Analysis, Systems, Applications", Second edition, 2011 Wiley.

1	**Code of the subject**	EE029
2	**Title of the subject**	Intelligent Control System
3	**Any prerequisite**	EE209
4	**L-T-P**	3-0-0
5	**Learning Objectives**	• Gaining an understanding of the functional operation of a variety of intelligent control techniques and their bio-foundations. • develop Neural Networks, Fuzzy Logic, and Genetic algorithms. • Implement soft computing to solve real-world problems mainly pertaining to control system applications.
6	**Brief Contents**	Introduction to Intelligent Control System Concepts, Control and Intelligent Systems, Dimensions of Intelligent Systems, Working Definitions, Techniques in Intelligent Control, Control System Architectures, Need for Learning, Learning and Adaptation, Learning Algorithms, Decision-Making Techniques, Neural Networks, Fuzzy Systems, Heuristic Optimization Techniques, Neural Network Architectures for

		Modeling and Control, System Identification and Control, Neural Network Based Control System, Architecture for Diagonal Recurrent Neural Network (DRNN), Convergence and Stability, Fuzzy Systems, Evolutionary Algorithms, Evolutionary Algorithms, Biological Basis, Genetic Algorithms (GA), Continuous and Discrete GA, Evolutionary Strategies, Evolutionary Programming; Differential Evolutionary Algorithm, Multiobjective Decision Problems, Pareto Multi-Objective Optimization, Swarm Intelligence
7	**Contents for lab**	NA
8	**List of textbooks/references**	• Fuzzy Control by Kevin M. Passino and Stephen Yurkovich, Addison-Wesley Longman Inc. • Fuzzy Control Systems Design and Analysis: A Linear Matrix Inequality Approach by Kazuo Tanaka, Hua O. Wang, John Wiley & Sons. • Artificial Intelligence: A Modern Approach by Stuart J. Russell and Peter Norvig, Pearson Education. • An Introduction to Genetic Algorithms by Melanie Mitchell, the MIT press. • Neural Network Learning and Expert Systems by Stephen I. Gallant, the MIT press. • Intelligent Systems: Modeling, Optimization, and Control, by Y. C. Shin and C. Xu, CRC Press: Boca Raton, FL. • Intelligent Systems and Control: Principles and Applications, by L. Behera and I. Kar, Oxford: New Delhi, India. • Intelligent Control: A Hybrid Approach Based on Fuzzy Logic, Neural Networks and Genetic Algorithms by N. Siddique, Springer: Switzerland.

1	**Code of the subject**	EE030
2	**Title of the subject**	Image Computing
3	**Prerequisite**	EE207
4	**L-T-P**	3-0-0
5	**Learning Objectives**	To equip students with the skills to process, analyze, and manipulate visual information using various techniques.
6	**Brief Contents**	Image Computing includes topics such as understanding image representation, covering formats, color models, and pixel-based representation. It explores image processing techniques like enhancement, filtering, and restoration. The course also delves into feature extraction and image analysis, focusing on pattern detection, edge detection, and texture analysis. Additionally, it covers various applications of image computing, including computer vision, transportation, and autonomous systems.
7	**Contents for lab**	NA

8	**List of textbooks/references**	• Image Computing: Theories and Applications by R. K. Gupta and B. L. Deekshatulu • Image Computing and Computer Vision by R. S. K. Lee • Digital Image Processing by Rafael C. Gonzalez and Richard E. Woods • Principles of Digital Image Processing: Core Algorithms by Wilhelm Burger and Mark J. Burge

1	**Code of the subject**	EE031
2	**Title of the subject**	Time-Frequency Analysis
3	**Prerequisite**	EE207
4	**L-T-P**	3-0-0
5	**Learning Objectives**	To enable students to analyze non-stationary signals by applying time-frequency transforms and techniques.
6	**Brief Contents**	Time-Frequency Analysis typically includes topics such as the fundamentals of signal representation in both time and frequency domains. It covers methods like the Short-Time Fourier Transform (STFT) and wavelet transform and their applications in analyzing non-stationary signals. The course explores signal processing techniques for time-varying signals, as well as applications in areas like autonomous system development and its analysis. It also addresses practical implementation and interpretation of time-frequency representations.
7	**Contents for lab**	NA
8	**List of textbooks/references**	• Time-Frequency Analysis: Theory and Applications by B. Boashash • The Fourier Transform and Its Applications by Ronald N. Bracewell • Wavelet Transform and Its Applications by Lokenath Debnath and Firdous A. Shah • Signal Processing and Linear Systems by B.P. Lathi

1	**Code of the subject**	EE032
2	**Title of the subject**	Machine Intelligence
3	**Prerequisite**	NA
4	**L-T-P**	3-0-0
5	**Learning Objectives**	To equip students with the knowledge of algorithms and techniques used in developing intelligent systems.
6	**Brief Contents**	Machine Intelligence focuses on core concepts such as machine learning algorithms, neural networks, and decision-making systems. It includes supervised and unsupervised learning and their applications in intelligent systems. The course also explores optimization techniques and problem-solving strategies. Finally, it emphasizes the real-world use of

		machine intelligence in automation, robotics, and data-driven decision-making.
7	**Contents for lab**	NA
8	**List of textbooks/references**	• Machine Intelligence by Rajendra Akerkar • Machine Intelligence: A New Era of Cognitive Computing by A. S. Sethi • Machine Intelligence and Knowledge Engineering for Decision Support by Lakhmi C. Jain • Machine Intelligence in Image Processing by R. S. S. Murthy

1	**Code of the subject**	EE033
2	**Title of the subject**	Speech and Audio Processing
3	**Prerequisite**	EE207, EE209
4	**L-T-P**	3-0-0
5	**Learning Objectives**	To equip students with the techniques for analyzing, processing, and enhancing speech and audio signals.
6	**Brief Contents**	Speech and Audio Processing covers the fundamentals of speech signal acquisition, representation, and analysis. It includes techniques for speech enhancement, feature extraction, and speech recognition. The course explores audio processing methods for tasks like compression, synthesis, and noise reduction. Additionally, it covers applications in speech synthesis, speaker recognition, and audio signal processing.
7	**Contents for lab**	NA
8	**List of textbooks/references**	• Speech and Audio Signal Processing: Processing and Perception of Speech and Music by Ben Gold and Nelson Morgan • Fundamentals of Speech Recognition by Lawrence Rabiner and Biing-Hwang Juang • Speech and Audio Processing for Coding, Enhancement, and Recognition by Philipos C. Loizou • Introduction to Audio Analysis: A MATLAB® Approach by Joshua D. Reiss and Andrew McPherson

1	**Code of the subject**	EE034
2	**Title of the subject**	Intelligent Vision Systems
3	**Prerequisite**	EE207, EE209
4	**L-T-P**	3-0-0
5	**Learning Objectives**	To provide students with the skills to analyze and interpret visual information from the world
6	**Brief Contents**	Intelligent Vision Systems covers the fundamentals of human vision, feature extraction, and image representation. It includes methods for object detection, motion analysis, and 3D reconstruction. The course also explores deep learning techniques such as convolutional neural networks

		(CNNs) for image recognition. Applications in areas like autonomous systems, and augmented reality are discussed.
7	**Contents for lab**	NA
8	**List of textbooks/references**	• Computer Vision: Algorithms and Applications by Richard Szeliski • Deep Learning for Computer Vision by Rajalingappaa Shanmugamani • Computer Vision: A Modern Approach by David A. Forsyth and Jean Ponce • Programming Computer Vision with Python by Jan Erik Solem

1	**Code of the subject**	EE035
2	**Title of the subject**	Biomedical Engineering
3	**Prerequisite**	NA
4	**L-T-P**	3-0-0
5	**Learning Objectives**	To provide students with knowledge of engineering principles applied to medical fields.
6	**Brief Contents**	Biomedical Engineering covers the fundamentals of instrumentation and processing of physiological signals such as ECG, EEG, and EMG. It includes techniques for signal filtering, feature extraction, and noise reduction. The course explores time-frequency analysis, pattern recognition, and statistical methods applied to biomedical signals. It also addresses the application of these techniques in medical diagnostics and health monitoring systems.
7	**Contents for lab**	NA
8	**List of textbooks/references**	• Introduction to Biomedical Engineering by John Enderle and Joseph Bronzino • Medical Instrumentation: Application and Design by John G. Webster • Biomedical Signal Processing and Analysis: A Practical Approach by S. R. Balakrishnan

CODE WITH ESxxx

1	**Code of the subject**	ES101
2	**Title of the subject**	Engineering Physics
3	**Prerequisite**	Basic knowledge of fundamentals of physics
4	**L-T-P**	3-0-2
5	**Learning Objectives**	Engineering Physics offers a multidisciplinary undergraduate program spanning engineering and physics in which fundamental physical principles are used to address research problems of technological importance at the frontiers of engineering and science. It promotes the understanding of the physical environment while discovering how physics is applied to problem-solving in our changing high-tech world. The engineering physics curriculum is designed to fulfill the educational requirements for professional work in various fields of applied science which are based upon a thorough knowledge of physics and foundation of basic scientific principles as well as the theoretical knowledge and skills required for specific engineering applications. Engineering physicists perform research and development in various industries pertaining to fields of telecommunications, microelectronics, lasers, fiber optics, nanotechnology and quantum computers.
6	**Brief Contents**	**Quantum Physics**: Black body radiation, Planck's hypothesis, wave particle duality, de-Broglie Hypothesis, Heisenberg uncertainty principle, photoelectric effect, Compton effect, phase and group velocity, wave function & its physical significance, Schrodinger's wave equation, Applications of Schrodinger equation. **Electrodynamics**: Maxwell's equations: differential and integral forms, significance of Maxwell's equations, displacement current and correction in Ampere's law, electromagnetic wave propagation, transverse nature of EM waves, applications, pointing vector & Poynting theorem. **Physics of Materials**: Types of Solids, Miller indices, Crystal structure, crystal systems, energy bands in solids, classification of solids, conductivity in metals and concepts of Fermi level, effective mass and holes, phonons, bulk and nanomaterials. Synthesis and characterization techniques, Graphene and 2D materials and its applications. **Laser and Fiber Optics**: Principles of lasers, Einstein Coefficients and their relations, Types of Lasers and their applications. Concept of optical fibers and types of optical fibers, modes of propagation, fiber optic communication, optical fiber sensors, connector and couplers.
7	**Contents for lab**	Practical experiments based on theory contents.
8	**Text /references**	● Engg. Physics- Kakani&Kakani, CBS Publications. ● David J Griffith, *Introduction to Quantum Mechanics, 2*nd ed., PHI, 2013. (Text Book). ● Avadhanulu, M. N, &Kshirsagar, S. G., *A Textbook of Engineering Physics*, S. Chand, 2014. (Text Book) ● Neeraj Mehta, *Applied Physics for Engineers*, PHI Learning Pvt. Ltd., 2011. (Text Book)

		● Fiber optic communication- J Keiser (McGraw Hill) (Text Book) ● David J Griffith, *Introduction to Electrodynamics*, 4th ed. , PHI, 2014. (Ref.). ● Paul Dirac, *Principles of Quantum Mechanics*, 4th ed., Oxford Uni. Press, 2004. (Ref.) ● Kittel, C., *Introduction to Solid State Physics*, 8th ed., Wiley, 2014. (Ref.) ● Malik and Singh, Engg Physics, TMH

1	**Code of the subject**	ES102
2	**Title of the subject**	Engineering Mathematics
3	**Any prerequisite**	None
4	**L-T-P**	3-1-0
5	**Learning Objectives**	● To explore the connections of mathematical foundation courses (Algebra, Calculus and Differential Equations) to the mathematics in the later engineering subjects. ● To provide platform for the exchange of ideas, practices and pedagogy in the mathematics education in engineering and technical institutions.
6	**Brief Contents**	Vector spaces over arbitrary field, subspaces, linear combination, spanning set, linear dependence and independence of vectors, basis and dimension of vector spaces. Linear Transformation, The Null Space and the Range Space of a Linear Transformation**,** Rank, Nullity, Rank-Nullity Theorem, Algebra of linear transformations, Isomorphism, Linear functionals, Annihilator, Transpose of a linear transformation. Matrix, matrix representation of a linear transformation, Rank of a matrix - echelon form, normal form, types of matrices-symmetric, skew-symmetric, Hermitian, skew-Hermitian, orthogonal, unitary matrices, consistency of system of linear equations (Homogeneous and Non-Homogeneous). Eigen values and Eigen vectors and their properties (Hermitian, Skew-Hermitian, Unitary matrices), Characteristic equations, Cayley-Hamilton theorem (without proof), Diagonalisation, Inner product, Norms of vectors, orthogonal vectors, Cauchy Schwarz Inequality, Triangle inequality. Introduction of function of two variables, Limit, Continuity, Differentiability, Partial differentiation, Maxima and minima for a function of several variables.
7	**Contents for lab**	NA
8	**Text /references**	1. Linear Algebra and its Applications, Gilbert Strang. 2. Fundamentals of Linear Algebra, James B. Carrell 3. Functions of Several Variables, Wendell Fleming 4. Linear Algebra: A geometric Approach, S Kumareson, PHI Learning,

1	**Code of the subject**	ES103
2	**Title of the subject**	Probability and Statistics
3	**Any prerequisite**	None
4	**L-T-P**	3-1-0
5	**Learning Objectives**	To introduce students about basics of probability theory and statistics.
6	**Brief Contents**	Introduction: Measures of Central Tendency, Measures of Dispersion, Measures of Skewness, and Measures of Kurtosis, Moments about mean and about any point. Probability: Basic terminology, Types of Probability, Probability rules, Bayes Theorem, Probability distribution, Binomial, Poisson, Negative-Binomial, Geometric, Hyper-geometric, Uniform, Exponential, Normal distribution, log-normal, beta and gamma distributions. Sampling: Types and Sampling Distribution, Random sampling, Relationship between sample size and standard error, Central limit theorem, Weak law of large numbers, estimation theory (MLE). Testing Hypotheses-1: One Sample Tests, Basics to hypotheses, Inference of single mean/proportion, Measuring the power of hypotheses test (z-test and t-test), P-values, interval estimation. Testing Hypotheses-2: Two Sample Tests, Testing for differences between means/proportions. Testing Hypotheses-3: Chi–Square distribution, Chi–Square as a test of independence, Testing the appropriateness of a distribution, Analysis of variance (ANOVA), Inference about a population variance (Chi-square test, F-test). Nonparametric tests: The sign-test, Rank-sum, test of randomness, Kolmogorov-Smirnov, Anderson-Darling test. Simple Regression and Correlation: Estimation using the regression line, Correlation analysis, making inferences about population parameters. Multiple Regression: Multiple regression and correlation analysis, Finding multiple regression equation, Inferences about population parameters.
7	**Contents for lab**	NA
8	**List of text books/references**	1. Johnson, R. A., Miller & Freund's Probability and statistics for engineers, Pearson Education, 2000. 2. Ross S. M., Introduction to Probability and Statistics for Engineers and Scientists, 5th Edition, Elsevier. 3. Hogg R. V., Craig A., Probability and Statistical Inference, 6th edition, Pearson Education.

1	**Code of the subject**	ES201
2	**Title of the subject**	Discrete Structures
3	**Prerequisite**	Engineering Mathematics
4	**L-T-P**	3-1-0

5	**Learning Objectives**	To prepare for a background in abstraction, notation, and critical thinking for the mathematics most directly related to computer science. To foster rigorous thinking skills that can enhance the quality of work of computing professionals. To relate and apply these concepts to practical applications of computer science.
6	**Brief Contents**	Fundamentals of Logic and their use in program proving, resolution principle. Set Theory and Functions, Group Theory, Elementary Combinatorics, Lattices and Boolean algebra, Graph Theory, Trees, Fundamental circuits, Cut sets, Graph colouring, covering, Partitioning etc.
7	**Contents for lab**	NA
8	**Text/references**	1.Bernanrd Kolman, Robert C Busby, S.Ross, Discrete Mathematical Structures, PHI Learning 2. Kenneth H. Rosen, Discrete Mathematics and Its Appications, Tata McGraw-Hill Edition 3. I.N. Herstein, Topics in Algebra, John Wiley Publications 4. Ralph P. Grimaldi, B.V. Ramana, Discrete and Combinatorial Mathematics, Pearson Education

1	**Code of the subject**	ES202
2	**Title of the subject**	Differential Equation and Integral Transformation
3	**Any prerequisite**	None
4	**L-T-P**	3-0-0
5	**Learning Objectives**	● To present the foundations of many basic Mathematical tools and concepts related Engineering. ● To provide a coherent development to the students for the courses of various branches of Engineering like ● Control Theory, Circuits and Networks, Digital Logic design, Fluid Mechanics, Machine Design etc. ● To enhance the student's ability to think logically and mathematically. ● To give an experience in the implementation of Mathematical concepts which are applied in various field of Engineering
6	**Brief Contents**	Formation and solution, Geometric meaning of y' = f(x,y), Direction fields, Exact differential equations, Reduction of Non exact differential equation using , Integrating factor, Linear differential equations, Bernoulli equations, Homogeneous equation –reduction to separable form ,Applications – Geometrical; tangent, normal of curves, orthogonal trajectories of curves. Growth and Decay. Higher Order Ordinary Differential Equations: Basic- General solution and particular integral, Auxiliary equation, complementary function. Linear differential equations of second and higher order: Homogeneous linear differential equations of second order, Euler-Cauchy Equations, Wronskian, Non-homogeneous equations, Solution by undetermined coefficients, Solution by variation of parameters. System simultaneous linear differential equations. Higher order linear differential equations,

		Higher order homogeneous with constant coefficient, Higher order non-homogeneous equations. Solution by [1/f(D)] r(x) method for finding particular integral. Applications- Mass spring Mechanical System -Free, damped, undammed & forced Oscillations. RLC circuits. Simple Pendulum. Partial Differential Equations and Applications: Basic Concepts-Formation PDEs, Order, Linearity & Homogeneity of PDE, Solution of Partial Differential equations f(x,y,z,p,q) = 0, Nonlinear PDEs first order, Some standard forms of nonlinear PDE, Linear PDEs with constant coefficients, Equations reducible to Homogeneous linear form, Non Homogeneous Linear PDE, Classification of second order linear PDEs. Method Separation of variables. Applications- One Dimensional Wave equation, One Dimensional Heat equation, Two Dimensional Laplace equation. Integral Transform Definition of the Laplace transform, Inverse Laplace transform, Linearity, Shifting theorem. Laplace transforms of derivatives and integrals. Unit step function, Dirac's delta function, Properties of inverse Laplace transform. Convolution Theorem. Complex inversion formula. Application of Laplace Transformation. Periodic function, Trigonometric series, Fourier series, Functions of any period, Even and odd functions, Half range Expansion.
7	**Contents for lab**	NA
8	**List of textbooks/references**	1. "Advanced Engineering Mathematics (8th Edition)", by E. Kreyszig, Wiley-India 2."Differential Equations",E.Rukumangadachari, Pearson. 3. "Elementary Differential Equations (8th Edition)",W. E. Boyce and R. DiPrima, John Wiley 4. M.D Raisinghania, Ordinary and Partial Differential Equations, S Chand & Co. 5. Gerald B Folland, Introduction to Partial Differential Equations, 2nd edition, Prentice – Hall of India 6. C. E. Froberg, Introduction to Numerical Analysis (2nd Edition), Addison-Wesley,

1	**Code of the subject**	ES203
2	**Title of the subject**	Real and Functional Analysis
3	**Any prerequisite**	None
4	**L-T-P**	3-0-0
5	**Learning Objectives**	• To Master the Foundations of Analysis • To Analyze Convergence and Continuity • To Develop Calculus and Integration Rigor • To Extend Concepts to Metric and Vector Spaces and to Apply Multivariate Calculus

6	**Brief Contents**	Definition of real numbers, field and order axioms, countable and uncountable sets, supremum and infimum of sets of real numbers, bounds and limit points of a set, Bolzano-Weierstrass theorem, open and closed sets, limit of sequence, bounded and monotonic sequences, Cauchy sequence and Cauchy general principle of convergence, product and quotient of limits, limit, limit superior, limit inferior of real functions, limit theorems, continuity and uniform continuity of real functions, properties of continuous functions, continuity and compactness. Differentiability of real functions, Taylor and Maclaurin's theorems, Riemann integration, conditions for integrability, properties of integrable functions, indefinite integral and their properties, fundamental theorem of integral calculus, mean value theorems, improper integrals, Sequences and series of functions, uniform convergence of sequences and series of functions. Regions in plane, level curves and level surfaces, limit, continuity, partial derivatives, directional derivatives and gradient, extreme values, differentiability. Metric spaces, complete metric spaces, norm spaces, Banach spaces, Banach contraction mapping theorem, bounded linear functionals and bounded linear operators, dual spaces. Hahn-Banach theorem, uniform boundedness principle, open mapping and closed graph theorems, weak convergence, Hilbert spaces, orthonormal sets, Riesz representation theorem, bounded linear operators on Hilbert spaces.
7	**Contents for lab**	NA
8	**List of text books/references**	1. Principles of Mathematical Analysis, Walter Rudin. 2. Functional Analysis: A First Course, Thamban Nair 3. Advanced Engineering Mathematics, Rajendra K. Jain and Satteluri R. K. Iyengar

1	**Code of the subject**	ES204
2	**Title of the subject**	Complex Analysis
3	**Any prerequisite**	None
4	**L-T-P**	3-0-0
5	**Learning Objectives**	This course is aimed to provide an introduction to the theory of function of a complex variable. The concepts of analyticity, Cauchy-Riemann equations and harmonic functions are introduced. Students will acquire the skill of contour integration to evaluate complicated real integrals.

6	**Brief Contents**	Function of a complex variable, Limit, Continuity, Uniform continuity, Differentiability, Analytic functions, Cauchy-Riemann equations, Harmonic functions and Harmonic conjugate. Exponential function, Trigonometric function, Logarithmic function, Branches of multi-valued functions Complex integration, Cauchy-Goursat theorem, Cauchy integral formula, Higher order derivatives, Morera's theorem, Liouville's theorem, Fundamental theorem of algebra, Zeroes of analytic function, maximum modulus principle, Schwarz's Lemma. Taylor's, Laurent's series, Singularities of complex functions, Casorati- Weierstrass theorem, Poles, Residues, Residue theorem and its applications to real integrals: Integration around unit circle, Integration over semi-circular contours (with and without real poles), Integration over rectangular contours, Argument principle, Rouche's theorem. Definition of conformal mapping, Bilinear transformation, Cross ratio, the mappings from disc to disc, disc to half plane and half plane to half plane. Poisson integral formula, Dirichlet problem in the unit disc, Dirichlet problem in the half plane.
7	**Contents for lab**	NA
8	**List of text books/references**	1. E.T. Copson, An Introduction to Theory of Functions of a Complex Variable, Oxford University Press (1970). 2. L.V. Ahlfors, Complex Analysis, Tata McGraw-Hill (1979). 3. S. Ponnusamy, Foundations of Complex Analysis, Narosa Publishing House (2007). 4. R.V. Churchill & J.W. Brown, Complex Variables and Applications, Tata McGraw-Hill (2008). 5. R.E. Greene & S.G. Krantz, Function theory of one complex variable, American Math. Soc. 3rd Ed. (2006).

1	**Code of the subject**	ES206
2	**Title of the subject**	Multivariate Data Analysis
3	**Any prerequisite**	None
4	**L-T-P**	3-0-2
5	**Learning Objectives**	Foundations and Distribution Theory: Understand and apply linear algebra and sampling theory fundamentals to multivariate data, and master the theory and properties of the Multivariate Normal Distribution (MVN) for use in statistical inference. Inference and Modelling: Conduct formal statistical inference (hypothesis testing and confidence region estimation) on single and multiple mean vectors, and construct and interpret multivariate response linear regression models. Data Structure and Dimension Reduction: Apply advanced techniques like Principal Components Analysis (PCA), Factor Analysis, and Canonical Correlation Analysis to explore and simplify the covariance structure, and utilize discrimination and clustering methods for classification and pattern discovery.

6	**Brief Contents**	**Getting started with multivariate:** Introduction, sampling theory, linear algebra, Multivariate normal distribution theory **Inference about mean vectors:** Inference on a single vector Inference on several mean vectors, Multivariate response linear regression, **Analysis of covariance structure:** Principal components, Factor analysis/factor models, Canonical correlations **Classification and clustering:** Discrimination andClustering
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**List of text books/references**	1. Applied Multivariate Statistical Analysis, 6th edition, Pearson/Prentice Hall 2007, by Johnson Richard A. and Wichern, Dean W. 2. Everitt, B. and Hothorn, T. An Introduction to Applied Multivariate Analysis with R. Springer 2011. 3. Koch, I. Analysis of multivariate and high-dimensional data. Cambridge University Press, 2013.

1	**Code of the subject**	ES205
2	**Title of the subject**	Advanced Numerical Methods
3	**Any prerequisite**	Mathematics-I, Mathematics-II
4	**L-T-P**	3-0-2
5	**Learning Objectives**	➢ To demonstrate understanding of common numerical methods and how they are used to obtain approximate solutions to otherwise intractable mathematical problems. ➢ To apply numerical methods to obtain approximate solutions to mathematical problems. ➢ To analyse and evaluate the accuracy of common numerical methods. ➢ To write efficient, well-documented MATLAB code and present numerical results in an informative way.
6	**Brief Contents**	Iterative Methods, Gauss Elimination Method, Gauss-Jordan Method, Gauss-Seidel Method, Convergence of Iterative Methods. Bisection Method, False Position Method, Newton-Raphson Method, Convergence of Bisection, False Position Methods, Fixed Point Iterative Method, Newton-Raphson's. Finite Difference Operators and Their Relationships, Difference Tables, Polynomial Interpolation, Newton Forward and Backward Interpolation Formula, Lagrange Interpolation Formula, Divided Difference Operator, Newton Divided Interpolation Formula. Differentiation Continuous Functions, Differentiation of Tabulated Functions, Higher Order Derivatives Newton-Cotes Integral Formula, Trapezoidal Rule, Simpson's Rules, Boole's Rule and Weddle's Rule, Romberg Integration Numerical solution of ODE's, Singlestep methods, Multistep methods, Predictor Corrector methods, Shooting methods Taylor Series Method, Picard's Method, Euler and Modified Euler Method, Runge-Kutta Methods, Milne's Method, Finite

		Differences Approximations of Partial Derivatives, Solution of Laplace Equation (Elliptic) By Standard 5 – Point Formula, Solution of One Dimensional Heat Equation (Parabolic) By Bender-Schmidt Method, Crank-Nicolson Method, Solution of One Dimensional Wave Equation (Hyperbolic) by Iterative Method.
7	**Contents for lab**	Numerical Simulations are based on the theoretical contents and their applications.
8	**List of text books/references**	1. Balagurusamy, E., Numerical Methods, Tata McGraw Hill Education Pvt. Ltd., 1999. 2. Sastry, S. S., Introductory Methods of Numerical Analysis, PHI Learning Pvt Ltd., 2012. 3. Jain, M. K., Iyengar, S.R.K and Jain, R.K, Numerical Methods for Scientific and Engineering computation, Wiley Eastern Ltd., 1985. 4. Elementary Numerical Analysis, Kendall Atkinson, Weimin Han, John Wiley and Sons, 2004

1.	**Code of the subject**	ES301
2.	**Title of the subject**	FUZZY SETS AND APPLICATIONS
3.	**Any prerequisite**	None
4	**L-T-P**	3 -0-0
5	**Learning Objectives**	The course aims to provide concepts of fuzzy sets and their applications to various disciplines such as Information Technology, Management and Engineering.
6	**Brief Contents**	Fuzzy sets – introduction, Basic types and Basic concepts, Additional properties of α-cuts, Representation of fuzzy sets, Extension principles. Type of operators on fuzzy sets and fuzzy complements, Fuzzy intersection and fuzzy unions, and Combination of operations. Fuzzy numbers and arithmetic operations on intervals, Arithmetic operations on fuzzy numbers, Fuzzy equations and fuzzy relations, Binary fuzzy relations and binary relation on a single set, Fuzzy equivalence relations. Fuzzy Arithmetics - Fuzzy number, Addition of fuzzy numbers, Subtraction of fuzzy numbers, Multiplication of fuzzy numbers, Division of Fuzzy numbers, Fuzzy Max and Fuzzy Min, L-R Fuzzy number, Triangular (or Trapezoidal) Fuzzy Number. Classification by equivalence relations-Crisp relations, Fuzzy relations, Cluster Analysis, Cluster Validity, c-means Clustering- Hard c-means (HCM), Fuzzy c-Means (FCM) Fuzzy Decision making – introduction, Conversion of linguistic variables to fuzzy numbers, Individual Decision Making, Multiperson Decision Making, Multicriteria decision Making, Fuzzy ranking methods.
7.	**Contents for lab**	NA
	Book(s)	1.George J.Klir, Bo Yuan, Fuzzy Sets and Fuzzy logic – Theory and Applications, Prentice Hall India, New Delhi, 1997.

		2.. H.J Zimmermann, Fuzzy sets, Decision making and expert systems, Kluwer, Bosten, 1987. 2. S.J. Chen and C.L.Hwang, Fuzzy Multiple Attributes Decision Making, Springer verlag, Berlin Heidelberg, 1992.

1	**Code of the subject**	ES302
2	**Title of the subject**	Trustworthy Artificial Intelligence
3	**Prerequisite**	Algorithms and Data Structures
4	**L-T-P**	3-0-2
5	**Learning Objectives**	To understand the techniques and concepts related to machine based reasoning systems through various applications of AI
6	**Brief Contents**	Introduction to AI and intelligent agents. Problem solving methods in AI, Informed and uninformed search strategies, knowledge representation, Uncertain Knowledge and Reasoning, Probabilities, Bayesian Networks. Bias in Artificial Intelligence, Responsible AI, Overview of different forms of learning, Learning Decision Trees, Artificial Neural Networks and Fuzzy Approaches; Logic in AI, Prolog, Modern AI language and tools etc.
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**Text /references**	1. S. Russell and P. Norvig, Artificial Intelligence: A Modern Approach, 2nd Ed, Prentice Hall, 2003 2. Elaine Rich and Kevin Knight. Artificial Intelligence, Tata McGraw Hill 3. Patrick Henary Winston, Artificial Intelligence, Pearson publication 4. Deepak Khemani. A First Course in Artificial Intelligence, McGraw Hill Education (India) 5. Eugene Charnaik and Drew McDermott, Introduction to Artificial Intelligence, Pearson publication 6. Nils John Nilsson, The Quest for Artificial Intelligence: A History of Ideas and Achievements, Morgan Kaufman 7. Dennis Rothman, Artificial Intelligence by Example

1	**Code of the subject**	ES303
2	**Title of the subject**	Vector Calculus
3	**Prerequisite**	None
4	**L-T-P**	3-0-0
5	**Learning Objectives**	To understand the techniques and concepts related to vector based systems through various applications of science and Engineering

6	**Brief Contents**	**Vector and scalars:** Vectors, Scalars, vector algebra, laws of vector algebra, unit vectors, scalar, vector field, dot and cross product, triple products, reciprocals set vectors. **Vector differentiation :** Ordinary derivatives of vectors, continuity and differentiability, differential formulas, partial derivative of vectors, directional derivative, and application, gradient, divergent and curl **Vector Integration:** Ordinary integrals of vectors, line integrals, surface and volume integrals, divergence, Strokes and related integrals. **Introduction to PDEs and Classification:** Formation of PDE, Types and Classification of PDEs. Existence and uniqueness theorem. **3 Big PDEs**: Conservation laws, Heat, Wave and Laplace Equation in 1D, Derivation and Physical Significance, Solution by separation of variable for various ICs & BCs. Numerical simulation of PDEs.
7	**Contents for lab**	NA
8	**Text /references**	1. W. Rudin. Principles of Mathematical Analysis, McGraw Hill Education 2. N. Piskunov, Differential and Integral Calculus, 3. W. Strauss. Partial Differential Equations - An Introduction 4. F. John , Partial differential equations , (Springer, 1982).

1	**Code of the subject**	ES304
2	**Title of the subject**	Software Reliability
3	**Any prerequisite**	None
4	**L-T-P**	3-0-0
5	**Learning Objectives**	Grasp Testing Foundations and Techniques: Distinguish between defects, faults, and failures, explain the role of testing and debugging in software quality, and apply different testing approaches, including Static Testing (e.g., control/data flow analysis) and Dynamic Testing (e.g., Black Box and White Box methods). Understand and Specify Software Reliability: Define Software Reliability, specify its attributes, and utilize basic Reliability Theory concepts, measurement processes, and metrics to analyze the core software reliability problem. Apply and Validate Reliability Models (SRGM): Understand the principles, assumptions, and differences among various Software Reliability Growth Models (SRGM), including

		Execution Time and Calendar Time models, and perform parameter estimation and model validation.
6	**Brief Contents**	**Fundamentals of Testing:** Human and errors, Defects, Faults, Failures, Defect Rate and Reliability, Defect Prevention, Reduction and Containment, Testing and Debugging, Software Quality **Approaches to Testing:** Static Testing, Structured Group Examinations, Static Analysis, Control flow & Data flow, Determining Metrics, Dynamic Testing, Black Box Testing, White Box Testing, Reliability testing, Acceptance testing **Software Reliability:** Defining Software Reliability, Software Reliability Attributes and Specification, Concept of Introduction to Measurement and Inspection Process, Documents and Metrics, Basics of Reliability Theory, Software Reliability Problem, Modeling Process, Software Reliability Models (SRGM), preliminary Concepts of Reliability Engineering, Parameter Estimation, Model Validation **Software Reliability Growth Models:** Execution Time Models, Calendar Time Models, Erlang Model, Modeling Fault Dependency and Debugging Time Lag, Testing Effort Dependent Modeling, Distributed Environment, Imperfect Debugging, Testing-Domain Models, Change-Point, Unified Approach Concepts, Artificial Neural Networks based SRGM, Introduction to Discrete SRGM
7	**Contents for lab**	NA
8	**List of text books/references**	1. Johnson, R. A., Miller & Freund's Probability and statistics for engineers, Pearson Education, 2000. 2 2. D Srinivasan and R Gopalswamy; "Software Testing: Principles and Practices", Pearson Education, 2006 3. Pham, Hoang. System software reliability. Springer Science & Business Media, 2007.

1	**Code of the subject**	ES305
2	**Title of the subject**	Quantum Computing
3	**Any prerequisite**	None
4	**L-T-P**	3-0-0
5	**Learning Objectives**	Foundations and Qubits: Master the mathematical basis of quantum information, using vector spaces and the postulates of quantum mechanics to model and manipulate qubits. Operators and Gates: Apply matrices and operators (e.g., Hermitian, unitary) to represent quantum operations, and construct quantum circuits using universal quantum gates (e.g., Hadamard, CNOT, Toffoli). Algorithms and Entanglement: Explain entanglement and Bell's theorem, and analyze the principles and significance of key quantum algorithms (Shor's, Grover's) and quantum cryptography (BB84).

6	**Brief Contents**	**Qubits and quantum states : C**lassical & quantum information, qubits, quantum computing and laws of physics, quantum information, quantum computers, vector spaces, postulates of quantum mechanics, linear combinations, basis & dimensions, inner products, Cauchy-schwartz and triangle inequalities. M**atrices & Operators** - Pauli operators, outer products & matrix representation, Hermitian, unitary & normal operators, eigenvalues and eigen vectors, characteristic equation, trace of an operator, expectation value of an operator, projection operators**.** **Entanglement & Quantum Gates:** Entanglement, exchange of information using entangled particles, Bell's theorem, Bipartite systems and the Bell basis. classical logic gates and circuits, one qubit quantum gates, the Hadamard gate, two qubit quantum gates- the CNOT gate, three qubit quantum gates- The Fredkin gate, The Toffoli gate, quantum circuits, universal quantum gates. **Quantum Algorithms & Cryptography:** classical to quantum Turing machines, computational complexity, quantum algorithms, quantum interference, Deutsch's algorithm, The Deutsch-Josza Algorithm, Shor's Algorithm, Grover's Algorithm, quantum cryptography, BB84-emergence of quantum cryptography, quantum noise and error correction.
7	**Contents for lab**	NA
8	**List of text books/references**	1. Quantum Computing Explained- David McMahon, Wiley Interscience 2. Quantum computing- Mika Hirvensalo 3. Quantum Computation and Quantum Information- Michael Nielsen & Chuang 4. An introduction to quantum computing- Phillip Kaye 5. Lectures on Quantum Information- Dagmar Brub, Gerd Leuchs 6. Quantum Computing- J. Stolze, Dieter Suter

1	**Code of the subject**	ES306
2	**Title of the subject**	Optimization Techniques
3	**Prerequisite**	Engineering mathematics, programming
4	**L-T-P**	3-1-0
5	**Learning Objectives**	To equip with the engineering problem formulation skills and optimization approaches to solve the problems along with quantitative analysis of those.
6	**Brief Contents**	Types of OR models, linear programming, problem formulation, graphical solution, simplex method, artificial variables techniques, two–phase method, big-M method etc. Transportation and assignment problems,

		Sequencing and Replacement, Theory of games and inventory, Dynamic Programming, engineering applications.
7	**List of text books/references**	1. J. K. Sharma, "Operations Research", Macmillan, 5th Edition, 2012. 2. R. Pannerselvan, "Operations Research", 2nd Edition, PHI Publications, 2006

1	**Code of the subject**	ES307
2	**Title of the subject**	Statistical Inference
3	**Any prerequisite**	None
4	**L-T-P**	3-1-0
5	**Learning Objectives**	Foundations and Distributions: Understand core statistical concepts (parameter, sampling distribution, standard error), state the Law of Large Numbers and CLT, and apply the properties of various distributions. Estimation: Evaluate estimators based on unbiasedness, consistency, efficiency, and sufficiency, and calculate parameter estimates and Confidence Intervals using the Method of Moments and Maximum Likelihood (MLE). Hypothesis Testing: State the concepts of errors, significance, and power, apply the Neyman-Pearson Lemma, and execute both large sample and small sample tests.

6	**Brief Contents**	**Concepts:** Population, Sample, Parameter, statistic, Sampling distribution, Standard error. convergence in probability and convergence in distribution, law of large numbers, central limit theorem (statements only). Student's t- distribution, F – Distribution, χ^2-Distribution: Definitions, properties and their applications. **Theory of estimation:** Estimation of a parameter, criteria of a good estimator – unbiasedness, consistency, efficiency, &sufficiency and. Statement of Neyman's factorization theorem. Estimation of parameters by the method of moments and maximum likelihood (M.L), properties of MLE's. Binomial, Poisson &Normal Population parameters estimate by MLE method. Confidence Intervals. **Testing of Hypothesis:** Concepts of statistical hypotheses, null and alternative hypothesis, critical region, two types of errors, level of significance and power of a test. One and two tailed tests. Neyman-Pearson's lemma. Examples in case of Binomial, Poisson, Exponential and Normal distributions. **Large sample Tests:** large sample test for single mean and difference of two means, confidence intervals for mean(s). Large sample test for single proportion, difference of proportions. standard deviation(s) and correlation coefficient(s). **Small Sample tests:** t-test for single mean,difference of means and paired t-test. □2-test for goodness of fit and independence of attributes. F-test for equality of variances.
7	**Contents for lab**	NA
8	**List of text books/references**	1. Statistical inference by George Casella, Duxbury advanced series 2. An Introduction to Probability and Statistics by V.K. Rohatgi & A.K. Md. E. Saleh. Modern Mathematical Statistics by E.J. Dudewicz& S.N. Mishra5. Introduction to the Theory of Statistics by A.M. Mood, F.A. Graybill and D.C. Boes

1	**Code of the subject**	ES308
2	**Title of the subject**	AI and Machine Learning
3	**Any prerequisite**	None
4	**L-T-P**	3-0-0
5	**Learning Objectives**	After successful completion of this course, students will be able to relate/understand/solve several day-to-day real-time problems with AI and machine learning algorithms. The objective of this course is to familiarize the students with different machine learning algorithms ranging from basic linear classifier/regression modelling problems to non-linear classification problems using deep-neural-network.

6	**Brief Contents**	**Introduction to Data Science and AI & ML:** Data Science, Use Cases in Business and Scope, Modeling Concepts, Data exploration (histograms, bar chart, box plot, line graph, scatter plot), Measure of Central Tendency , Measure of Positions, Measure of Dispersion, Relationship between attributes: Covariance, Correlation Coefficient, Chi Square, Measure of Distribution (Skewness and Kurtosis), Probability Distribution **Predictive Analytics:** Sampling and Estimation, Linear Regression, Multiple Linear Regression, Non-Linear Regression. **Machine Learning:** Foundations for ML, Clustering, Naïve Bayes Classifier,K-Nearest Neighbors, Support Vector Machines, Decision Trees, Ensembles methods. **Artificial Intelligence:** Foundations for AI, Convolution Neural Networks: AlexNet, VGG architectures, Recurrent Neural Networks, Deep Learning, Introduction to auto-encoder and generative adversarial networks (GAN)
7	**Contents for lab**	NA
8	**List of text books/references**	1. Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, Mathematics for Machine Learning, Cambridge University Press 2. Tom M. Mitchell, Machine Learning - McGraw Hill Education, International Edition 3. Aurélien Géron, Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow, O'Reilly Media, Inc. 2nd Edition

1	**Code of the subject**	ES401
2	**Title of the subject**	Modelling and Simulation
3	**Any prerequisite**	Engineering Mathematics and Probability & Statistics
4	**L-T-P**	3-0-2
5	**Learning Objectives**	To teach the application of mathematics and statistics in real life problems.
6	**Brief Contents**	Introduction: Concept of a system, System Environment, Modelling and Simulation of Real world problems, Classification of Models and examples, Static and Dynamic models. Principles used in modelling System Studies: Subsystems, A Corporate models, Block diagram of modelling and simulation. System Analysis, System Design Mathematical Models: Mathematical models in population dynamics, Epidemic Models, some mathematical modelling in Biology and Medicine Innovation diffusion models in marketing System. Simulation: The technique of simulation, the Monte Carlo Method, Types of system simulation, Continuous and Discrete time Simulation. Probability Concepts in Simulation: Stochastic variables, Discrete and continuous probability distributions, Measures of probability functions, Random numbers generation,

		Stochastic Processes: Poisson Process, Markov Process, Queuing Theory, Reliability. Software in System Simulation: Numerical computation technique for continuous and discrete models (MATLAB)
7	**Contents for lab**	As per the theoretical contents
8	**List of text books/references**	1. Banks, J., Carson, I. I., Nelson, B. L., &Nicol, D. M. (2005). Discrete-event system simulation. Pearson. 2. Kishor S Trivedi, Probability & Statistics With Reliability, Queuing And Computer Science Applications, 2nd Ed, Wiley. 3. Geoffrey Gordon, System Simulation, Prentice-Hall. 4. B. Barnesa and GR Fulford, Mathematical Modeling with Case Studies, A Differential Equations Approach using Maple and MATLAB, Second Edition

1	**Code of the Subject**	ES402
2	**Title of the Subject**	Data Mining and Data Warehousing
3	**Any Prerequisite**	Basic understanding of databases, statistics, and programming
4	**L-T-P**	3-0-2
5	**Learning Objectives**	● Extract knowledge using data mining techniques ● Design a data mart or data warehouse for any organization ● Explore recent trends in data mining such as web mining, spatial-temporal mining
6	**Brief Contents**	Data Mining Concepts: Input, Instances, Attributes and Output, Knowledge Discovery process, Data preprocessing, Data Cleaning, Data Integration & Transformation, Data Reduction, Data Warehouse, Data Warehousing schemas, Data cube analysis, Mapping Data Warehouse to Multiprocessor Architecture, DBMS Schemas for Decision Support; Associations: Maximal Frequent & Closed Frequent item sets, Covering Algorithms & Association Rules, Mining Association Rules from Transactional databases, Apriori algorithm, Variations of Apriori algorithm, FP-growth algorithm, Mining Association Rules from Relational databases, Correlation analysis & Constraint-based Association Mining, Multi-level and Multidimensional association mining; Classification & Prediction: Issues regarding Classification & Prediction, Classification by Decision Tree induction using Information gain, Gini indexing method, Bayesian classification, Classification by Back Propagation, k-Nearest Neighbor Classifiers, SVM algorithm; Clustering Analysis: Types of data in Clustering Analysis, Categorization of Major Clustering methods, Hierarchical methods, Distance-based methods, Density-based methods,

		Grid-based methods, Model-based Clustering methods; Applications of Data Mining: Text mining, TF-IDF model for text mining, Web page mining, Recommender systems building, Fuzzy set theoretical approach in data mining.
7	**Contents for lab**	Programming of association mining, classification and clustering algorithms
8	**List of textbooks/references**	• **Jiawei Han and Micheline Kamber,** *Data Mining: Concepts and Techniques,* Morgan Kaufmann Publishers, 2000 (ISBN: 1-55860-489-8). • **Ian H. Witten and Eibe Frank,** *Data Mining: Practical Machine Learning Tools and Techniques with Java implementations,* Morgan Kaufmann Publishers, San Francisco, CA (2000). • **D Pyle,** *Data Preparation for Data Mining,* Morgan Kaufmann, (1999).

1	**Code of the subject**	ES403
2	**Title of the subject**	Advanced Graph Theory
3	**Any prerequisite**	None
4	**L-T-P**	3-0-0
5	**Objectives of the subject**	1. To develop ability to solve real life problems, translating them one form to another, using appropriate mathematical and computational techniques 2. To prepare abstract and critical mathematical thinking,most directly related to computer science 3. To foster rigorous thinking skills that can enhance the quality of work of computing professionals 4. To relate and apply the concepts to practical applications of computer science
6	**Brief Contents**	Introduction to graphs: Finite and Infinite Graphs, Incidence and Degree, Isolated Vertex, Pendant Vertex, and Null Graph, Subgraphs: Walks, Paths and Circuits Isomorphism, 1-isomorphism, 2-isomorphism, circuit correspondence Connected Graphs, Disconnected Graphs, and Components, Euler Graph, Hamiltonian Graph. Trees and Fundamental Circuits: Spanning Tree, Rooted and Binary Trees, Matrix Tree Theorem,

		Cut-sets and Cut vertices: Fundamental Circuits and Cut-Sets, Connectivity and Separability, Network Flows, Planar and Dual graphs: Embedding, Detection of Planarity, Kurtowski Theorem, Euler Identity. Matrix representation of Graphs: Incidence Matrix, Fundamental Circuit Matrix and Rank of B, Cut-Set Matrix, Path Matrix. Coloring, Covering and Partitioning: Chromatic number, Chromatic polynomial, Coverings, Underlying graph, Outdegree, in-degree, Connectivity, Orientation, Directed graph: Eulerian directed graphs, Hamilton directed graphs.
7	**Contents for lab**	NA
8	**List of text books/references**	1. Narsingh Deo, Graph Theory with Applications to Engineering And Computer Science, Prentice Hall of India, 1992 2. West, Douglas B., Introduction to Graph Theory, Pearson Education, 2002 3. Reinhard Diestel, Graph Theory, Springer International Edition, 2004

1	**Code of the subject**	ES404
2	**Title of the subject**	Modern Cryptography
3	**Any prerequisite**	None
4	**L-T-P**	3-0-2
5	**Learning Objectives**	1. To develop a framework to understand and implement cryptographic aspects. 2. To enhance an ability to analyze a problem, and identify and define the computing requirements for data security. 3. To prepare abstract and critical thinking background for Data sciencestudents.

6	**Brief Contents**	Classical Encryption Techniques: Symmetric Cipher Model, Substitution Techniques, Transposition Techniques, Stream Cipher and Block Cipher, Random Number Generator, One-time Pad.Groups, Rings, Fields, Modular Arithmetic, Euclid's Algorithm, Finite Fields of Form GF (p) And GF (2^n). Polynomial Arithmetic, Prime Numbers, Fermat's And Euler's Theorem, Testing for Primality, The Chinese Remainder Theorem. Block Cipher Principles, Data Encryption Standard (DES), Multiple Encryption, Triple DES, Advanced Encryption Standard (AES).Principles of Public Key Cryptosystems, The RSA Algorithm, Key Management, Diffie–Hellman Key Exchange, Discrete Logarithm Problem, Elgamal Encryption Scheme, Elliptic Curve Arithmetic, Elliptic Curve Cryptography.Authentication Requirement, Authentication Function, MAC, Hash Functions, Security of Hash Function, Digital Signatures.
7	**Contents for lab**	Programming session for different symmetric/ asymmetric algorithms.
8	**List of text books/references**	1. William Stallings, Cryptography and Network security, 7e, Prentice Hall of India, New Jersey, 2017. 2. Christof Paar, Jan Pelzl, Understanding Cryptography, Springer-Verlang, Berlin, 2010. 3. Behrouz A Forouzan, Cryptography and Network security, Tata Mc-Graw Hill, New York, 2008.

1	**Code of the subject**	ES498
2	**Title of the subject**	Colloquium (Based on industrial training)/ MOOC
3	**Prerequisite**	None
4	**L-T-P**	0-0-6
5	**Learning Objectives**	To instill the ability to identify skills and gain practical work experience To provide an opportunity to observe and contribute in the workplace To take ownership and responsibility of a project assignment, given by a designated manager/supervisor To provide networking opportunities with other members of the organization To offer performance feedback and mentorship throughout the internship
6	**Brief Contents**	An internship helps you train under experienced professionals and explore what your chosen career path would be like, and an internship with a company in your field can help you to develop the skills you require to thrive within a professional setting. At the end of the training period, the company may ask you to review your time with them and write a report based on your experience. In addition, hone the skills needed to develop internship report.

7	**Contents for lab**	There are no specific laboratory sessions for this. However, this being a completely practical oriented course, the student has to devote significant time to achieve the objectives.
8	**Text /references**	1. https://www.careereducation.columbia.edu/resources/10-tips-make-most-internship 2. https://in.indeed.com/career-advice/career-development/internship-report

1	**Code of the subject**	ES499
2	**Title of the subject**	BTech Project/ Internship
3	**Any prerequisite**	None
4	**L-T-P**	0-0-24
5	**Learning Objectives**	To develop deeper knowledge, understanding, capabilities and attitudes in the context of the programme of study.
6	**Brief Contents**	The purpose of this course is to enable the student to develop deeper knowledge, understanding, capabilities and attitudes in the context of the programme of study. The student is expected to demonstrate the abilities of the major subject/field of study, including deeper insight into hardware/software application development work. Develop the capability to create, analyse and critically evaluate different technical/architectural solutions. Equip with the needed skills to clearly present and discuss the conclusions as well as the knowledge and arguments that form the basis for the learning outcome in written and spoken English. Importantly it is necessary to march on the ethical aspects of research and development work.
7	**Contents for lab**	There are no specific laboratory sessions for this. However, this being a completely practical oriented course, the student has to devote significant time to achieve the objectives.
8	**List of text books/references**	https://grad.wisc.edu/wp-content/uploads/sites/329/2018/02/2018-Project-Management-for-Graduate-Students-Course-Workbook.pdf

1	**Code of the subject**	ES001
2	**Title of the subject**	Parallel Computing
3	**Any prerequisite**	Basic knowledge of computer architecture, programming, and algorithms
4	**L-T-P**	3-0-2
5	**Learning Objectives**	• Understand parallel computing concepts and architectures including shared and distributed memory systems, multi-core processors, and GPU computing. • Develop and implement parallel algorithms using programming models like CUDA, focusing on performance, scalability, and efficiency.

		• Analyze and optimize parallel programs by handling synchronization, communication, and load balancing to solve real-world computational problems effectively.
6	**Brief Contents**	Parallel Processing Concepts: Levels of parallelism; computational models such as SIMD, MIMD, SIMT, SPMD, Dataflow Models, and Demand-driven Computation; N-wide superscalar architectures; multi-core and multi-threaded processors. Parallel Programming with CUDA: Processor architecture, interconnects, communication mechanisms, memory organization, and programming models in high-performance computing systems (Examples: IBM Cell BE, NVIDIA Tesla GPU, Intel Larrabee microarchitecture, and Intel Nehalem microarchitecture); memory hierarchy and transaction-specific memory design; thread organization and execution. Fundamental Design Issues in Parallel Computing: Core limitations in parallel computing; challenges in scalability and efficiency; power-aware computing and energy-efficient communication strategies. Advanced Topics: Petascale computing systems; role of optics in parallel computing; quantum computing paradigms; recent advancements in nanotechnology and their impact on high-performance computing (HPC).
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**List of textbooks/references**	• **Ananth Grama, Anshul Gupta, George Karypis, and Vipin Kumar,** *Introduction to Parallel Computing.* • **David A. Bader (Ed.)** *Petascale Computing: Algorithms and Applications,* Chapman & Hall/CRC, Computational Science Series.

1	**Code of the subject**	ES002
2	**Title of the subject**	Computational Biology
3	**Any prerequisite**	None
4	**L-T-P**	3-0-0
5	**Learning Objectives**	• Foundational understanding (conceptual knowledge) Analytical & computational skills (modeling & problem-solving) Applications & critical thinking (biological interpretation & future directions)
6	**Brief Contents**	Introduction to Mathematical Modelling, Dynamic Modelling of Biological Systems: Introduction, Solving ODEs & Parameter

		Estimation methods, Modelling in Drug Development, Host-pathogen interactions, Robustness of Biological Systems. Introduction to Static Networks, Networks and graph theory, Network Biology and Applications, Reconstruction of Biological Networks, Gene-regulatory network, Protein-interaction network, Metabolic networks and Signaling network; Inter-cellular networks: Neuronal networks, Network motifs, Network medicine. Constraint-based approaches to Modelling Metabolic Networks, Perturbations to Metabolic Networks. Elementary Modes, Applications of Constraint-based Modelling. Constraint-based Modelling Recap, Metabolic Flux balance Analysis: Translating biochemical networks into linear algebra, Stoichiometric matrix, Extreme pathway. Modelling Regulation, Advanced topics: Robustness and Evolvability, Introduction to Synthetic Biology, Perspectives & Challenges
7	**Contents for lab**	NA
8	**List of textbooks/references**	1. Murray JD, Mathematical Biology, IIIrd Edition. 2. Voit E, A First Course in Systems Biology. Garland Science (2012). 1/e. ISBN 0815344678 3. Introduction to Systems Biology: Design Principles of Biological Circuits by Uri Alon, Chapman & Hall/CRC, 2007. 4. Networks: An Introduction by M.E.J. Newman, Oxford University Press, 2010 5. Klipp E, Systems biology: a textbook. Wiley-VCH (2009). 1/e. ISBN 9783527318742

1	**Code of the subject**	ES003
2	**Title of the subject**	Stochastic Processes and Applications
3	**Any prerequisite**	None
4	**L-T-P**	3-1-0
5	**Learning Objectives**	Many complex systems are modelled using stochastic processes. This course will introduce students to basic stochastic process tools that can be utilized for performance analysis and stochastic modelling.
6	**Brief Contents**	Review of probability, random variable, and expectation Stochastic processes, Discrete-Time Markov Chains, Continuous-Time Markov Chains, Queuing networks
7	**Contents for lab**	NA
8	**List of text books/references**	1. Introduction to Stochastic Processes‖, E. Cinlar, Prentice-Hall, 1975. 2. Stochastic Modelling of Queues‖, R. W. Wolf, Prentice-Hall, 1989.

		3. Probability & Statistics with Reliability, Queuing and Computer Science Application‖, 2nd ed., Wiley, 2008.

	Code of the subject	ES 004
2	**Title of the subject**	Topology and Differential Geometry
3	**Any prerequisite**	Real Analysis
4	**L-T-P**	3-1-0
5	**Learning Objectives**	Curves and Surfaces are basic geometric objects that appear naturally in various fields of science and engineering. It is worthwhile to understand the intrinsic geometry of curves & surfaces.
6	**Brief Contents**	Topological spaces: the basic axioms of topology with examples, Bases and Subbases, Various kinds of topologies on the real line, Review of topology and multivariable calculus, Definition and examples of smooth manifolds, Smooth maps between manifolds, submanifolds, Tangent spaces and vector fields, Lie brackets and Frobenius theorem,: Lie groups and Lie algebras.
7	**Text /references**	1. Anant R. Shastri Basic Algebraic Topology, CRC Press, 2014 2. M.J. Greenberg and J. R. Harper, Algebraic Topology, Benjamin/Cummings Pu Munkres.

1	**Code of the subject**	ES005
2	**Title of the subject**	Data Economics
3	**Any prerequisite**	None
4	**L-T-P**	3-0-0
5	**Learning Objectives**	To provide a well-founded educational base as well as a well-resourced learning environment in Quantitative Economics and Data Sciences for formulating and analysing real-world problems with a sustainable approach
6	**Brief Contents**	Economics: - Public Policy, Health Economics, Environmental Economics, Agricultural Economics, Industrial Economics, Growth Theory, Labour Economics, International Macroeconomics and Policies, and International Finance. Finance: -Quantitative Finance, Computational Finance, Corporate Finance, Financial Econometrics, and International Finance.
7	**Text /references**	1. Brahmaiah, B. and P. Subba Rao, Financial Futures and Options, Himalaya Publishing House, Mumbai, 1998. 2. Chi-Fu Huang and R.H. Litzenberger, Foundations for Financial Economics. North Holland, New York, 1988.

		3. Isaac Baley, Laura L. Veldkamp, The Data Economy: Tools and Applications, Princeton University Press, 2025.

1	**Code of the subject**	ES006
2	**Title of the subject**	Intuitionistic Fuzzy Sets and Applications
3	**Any prerequisite**	Fuzzy Sets and Applications
4	**L-T-P**	3-1-0
5	**Learning Objectives**	The course aims to provide concepts of intuitionistic fuzzy sets and their applications to various disciplines.
6	**Brief Contents**	Introduction to intuitionistic fuzzy sets –Basic types and Basic concepts, Definition and additional properties of -cuts, Representation of intuitionistic fuzzy sets Intuitionistic Fuzzy Arithmetics - Intuitionistic Fuzzy number, Addition of Intuitionistic fuzzy numbers, Subtraction of Intuitionistic fuzzy numbers, Multiplication of Intuitionistic fuzzy numbers, Different types of Intuitionistic Fuzzy Numbers and their properties. Interval-valued intuitionistic fuzzy sets, triangular intuitionistic fuzzy numbers, trapezoidal intuitionistic fuzzy numbers, various generalizations of fuzzy and intuitionistic fuzzy sets, Various ordering principles on the set of intuitionistic fuzzy sets. Ordering principle- Total ordering, partial ordering, de intuitionistic fuzzification, ranking principles and their properties. Score function, accuracy function, left spread, right spread, and complete score. Different ordering principles on the classes of intuitionistic fuzzy sets. Distance Measure, Divergence Measure, Entropy, Similarity measures on the various classes of intuitionistic fuzzy sets. Introduction to Aggregation operators involve Arithmetic mean, geometric mean, Dombi mean, Heronian Mean, Benferonni Mean, T-norm, T-conorm, etc., and their Mathematical properties. Applications to Decision Science: Uncertainty Modelling, Decision-making under intuitionistic fuzzy environment, Generalizations of recent MCDM Methods, TOPSIS, AHP, ANP, etc.
7	**Text /references**	1.George J.Klir, Bo Yuan, Fuzzy Sets and Fuzzy logic – Theory and Applications, Prentice Hall India, New Delhi, 1997. 2. H.J Zimmermann, Fuzzy sets, Decision making and expert systems, Kluwer, Bosten, 1987. 3. S.J. Chen and C.L.Hwang, Fuzzy Multiple Attributes Decision Making, Springer verlag, Berlin Heidelberg, 1992. 4. Relevant Research articles

1	**Code of the subject**	ES007
2	**Title of the subject**	Financial Mathematics
3	**Prerequisite**	User applications and some aspects of the process and their interaction
4	**L-T-P**	3-0-0
5	**Learning Objectives**	Understand the purpose and overview of the Internetworking technology, issues, and approaches using a top-down philosophy.
6	**Brief Contents**	Mathematical introduction, Growth and decay curves. Simple interest, bank discount, Compound interest, discrete compounding, Compounding frequency of interest, Economic equivalence, Method of comparison of alternatives, Project balance, Credit and loan, Cost of credit and amortization, Depreciation and depletion, Breakeven analysis, Leverage Stocks and bonds, Valuation of stocks and bonds, Mutual funds, Options, Cost of capital and ratio analysis, Decision under risk &uncertainty, Risk premium, Portfolio diversification, Life Insurance, Endowment, and annuities, Insurance policies
7	**Contents for lab**	NA
8	**Text /references**	1.Marek Capinski and Tomasz Zastawniak, "Mathematics for Finance", Springer. 2. Ambad Nazri Wahidudin, "Financial Mathematics and its Applications", Ventus Publishing ApS

1	**Code of the subject**	ES008
2	**Title of the subject**	Digital Image Processing
3	**Prerequisite**	Basic understanding of linear algebra, and programming
4	**L-T-P**	3-0-2
5	**Learning Objectives**	To introduce the basic concepts of Digital image processing with emphasis on applications in various field of recent research.
6	**Brief Contents**	Introduction and Fundamentals: Definition, history, and applications of digital image processing; image types (binary, grayscale, color); image acquisition methods and sampling; pixel representation, resolution, and color models (RGB, CMYK, HSV); hardware and software components; common image formats (JPEG, PNG, TIFF); intensity transformations and basic image operations. Image Enhancement in Spatial Domain: Gray-level transformations (negative, contrast stretching, thresholding); histogram equalization and matching; spatial filtering (mean, median, Laplacian, gradient); arithmetic and logical enhancement techniques; noise reduction using spatial filters. Image Enhancement in Frequency Domain: 2D Fourier transform and properties; frequency domain filtering (ideal, Butterworth,

		Gaussian); homomorphic filtering for contrast and dynamic range; DCT-based enhancement and compression techniques. Image Restoration: Degradation models (blur, noise); noise types (Gaussian, impulse, uniform); restoration methods including inverse filtering, Wiener filtering, constrained least squares, and blind deconvolution. Segmentation: Segmentation basics and challenges; thresholding (global, adaptive); edge-based methods (Sobel, Prewitt, Canny, LoG); region-based (growing, splitting/merging); clustering methods (K-means, fuzzy C-means); morphological segmentation (opening, closing, watershed). Representation and Description: Boundary representation (chain codes, polygons); region representation (run-length, connected components); boundary descriptors (Fourier, shape signatures); region descriptors (area, perimeter, moments); texture analysis (statistical, structural, spectral); feature extraction for classification.
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**Text /references**	● Rafael C. Gonzalez and Richard E. Woods, *Digital Image Processing,* 2nd Edition, Pearson Education. ● R. J. Schalkoff, *Digital Image Processing and Computer Vision,* John Wiley and Sons, New York. ● William K. Pratt, *Digital Image Processing,* John Wiley and Sons, New York.

1	**Code of the subject**	ES009
2	**Title of the subject**	Big Data Analytics
3	**Any prerequisite**	Basic knowledge of statistics, programming, and distributed computing
4	**L-T-P**	3-0-2
5	**Learning Objectives of the subject**	The course focuses on big data computer systems, storage, processing, analysis, visualization, and applications. State-of-the-art computational frameworks for big data.
6	**Brief Contents**	Overview of Big Data: Definition, 3 Vs (Volume, Velocity, Variety) plus Veracity, Value, Variability; sources like social media and sensors; applications and challenges. State-of-the-art Computing Paradigms: Distributed, cloud, edge/fog computing; serverless/FaaS; HPC; batch vs. stream processing. Big Data Programming Tools: Hadoop (HDFS, MapReduce, YARN), NoSQL databases (MongoDB, Cassandra), Apache Spark,

		real-time tools (Flink, Storm), data ingestion (Kafka, NiFi), orchestration (Airflow). Big Data Extraction and Integration: Handling structured/unstructured data, ETL pipelines, cleaning, transformation, federation, metadata; tools like Talend, Informatica. Big Data Storage: Distributed file systems (HDFS, S3), data lakes vs warehouses, columnar formats (Parquet, ORC), NoSQL models, cloud and hybrid storage. Big Data Privacy: Anonymization, differential privacy, encryption techniques, compliance (GDPR, CCPA), privacy-preserving mining. Big Data Visualization: Dashboards, graphs, heatmaps, tools (Tableau, Power BI, D3.js), interactive and real-time visualizations, handling high-dimensional and streaming data.
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**List of text books/references**	● Kuan-Ching Li, Hai Jiang, Laurence T. Yang, and Alfredo Cuzzocrea, *Big Data: Algorithms, Analytics, and Applications,* Chapman & Hall/CRC Big Data Series, 2015. ● Thomas Erl, Wajid Khattak, and Paul Buhler, *Big Data Fundamentals: Concepts, Drivers & Techniques,* The Prentice Hall Service Technology Series, 2016. ● Wajid Khattak, Paul Buhler, and Thomas Erl, *Big Data Fundamentals: Concepts, Drivers & Techniques,* John Wiley & Sons, Inc.

1	**Code of the subject**	ES010
2	**Title of the subject**	Wavelet Analysis
3	**Any prerequisite**	None
4	**L-T-P**	3-0-0
5	**Learning Objectives**	To expose the students to the basics of wavelet theory and to illustrate the use of wavelet processing for data compression and noise suppression.
6	**Brief Contents**	● Properties of Fourier transform, inversion of Fourier transform, relation between Fourier Transform and DFT (Discrete Fourier Transform), Convolution-an introduction, Fourier transform in L2 (IR), Parseval formula, Plancherel relation, Poission summation formula, summation kernels arising from Poission summation. ● Basic aspects of Fourier series, definition of Fourier series, examples of Fourier series, Fourier series of real functions, pointwise convergence of Fourier series, further aspects of

		convergence of Fourier series, Fourier since series, Fourier cosine series, convergence of Fourier sine & cosine series. Some application of Fourier series, Heat equation, the wave equation, Schrodinger's equation of free particles, Filters used in signal processing, designing filter, convolution and point spread function. ● The continuous wavelet transform, Parseval formula for wavelet transform, inversion formula, properties of wavelet transform, discrete wavelet transform, frames, frame operator and its properties, orthonormal wavelets, definition of multiresolution analysis and examples, properties of scaling functions and orthonormal wavelet bases, construction of wavelets.
7	**Text /references**	1. Daubechies, I. (1992). Ten Lectures on wavelets. SIAM. – A foundational text covering both theoretical and applied aspects of wavelets. Mallat, S. (2008). 2. A Wavelet Tour of Signal Processing. Academic Press. – Comprehensive coverage of wavelet methods in signal and image processing. Walnut, D. F. (2002).

1	**Code of the subject**	ES011
2	**Title of the subject**	Introduction to Game Theory
3	**Any prerequisite**	None
4	**L-T-P**	3-0-0
5	**Learning Objectives**	1. Understanding the basic game theory concepts, including utility, strategies, and Nash equilibrium. 2. Knowledge of advanced game theory concepts, such as repeated games, signalling games, and mechanism design. 3. Understanding the limitations of game theory and its relationship to other decision-making frameworks. 4. Developing critical thinking skills and the ability to apply game theory to evaluate and design strategies in different domains. 5. Knowledge of the use of game theory in various fields, such as economics, political science, and computer science.
6	**Brief Contents**	● Normal Games and Nash Equilibrium, ● Mixed Strategies, ● Sequential Games, ● Games with Incomplete Information. ● Auctions ● Repeated Games ● Cooperative Games ● Bargaining and Negotiation
7	**List of text books/references**	1. Nisan Roughgarden, Tardos, Vazirani (eds), Algorithmic Game Theory, Cambridge University, 2007 2. Maschler, Michael, Shmuel Zamir, and Eilon Solan. Game theory. Cambridge University Press, 2020.

		3. Narahari, Yadati. Game theory and mechanism design. Vol. 4. World Scientific, 2014.

1	**Code of the subject**	ES012
2	**Title of the subject**	Computer Vision
3	**Any prerequisite**	Basic knowledge of linear algebra, calculus, probability, and programming
4	**L-T-P**	3-0-2
5	**Learning Objectives**	● Understand core concepts of Computer Vision, including multi-dimensional signal processing, feature extraction, pattern analysis, visual geometric modeling, and stochastic optimization. ● Develop algorithms and techniques to analyze and interpret visual data from the surrounding environment. ● Explore applications such as biometrics, medical diagnosis, document processing, visual content mining, surveillance, and advanced rendering.
6	**Brief Contents**	Fundamentals of Computer Vision, Affine and Projective Transformation: Introduction to the principles of computer vision, image formation, and camera geometry. Overview of affine and projective transformations used for image alignment, registration, and geometric corrections; Convolution and Filtering, Image Enhancement, Histogram Processing: Fundamentals of convolution in image processing. Spatial and frequency domain filtering. Techniques for image enhancement such as contrast adjustment and smoothing. Histogram equalization and matching for intensity distribution control; Image Segmentation, Region Growing, Edge-Based Segmentation, Graph-Cut, Texture Segmentation: Techniques for dividing images into meaningful regions. Region growing based on pixel similarity. Edge-based methods using gradients. Graph-Cut for energy minimization-based segmentation. Texture segmentation using local pattern analysis; Object Detection, Filters, Edge Detection Techniques (Canny, Sobel, Prewitt): Detection of objects in images using filtering and pattern recognition. Edge detection techniques including Sobel, Prewitt, and Canny operators for identifying object boundaries. K-Means, K-Medoids Clustering, Optical Flow, Spatio-Temporal Analysis, Dynamic Stereo, Motion Parameter Estimation:

		Unsupervised clustering using K-Means and K-Medoids. Optical flow for motion estimation in image sequences. Spatio-temporal analysis for video understanding. Stereo vision for depth from motion and estimation of camera parameters; Light at Surfaces, Phong Model, Reflectance Map, Albedo Estimation: Modeling how light interacts with surfaces. Phong reflection model for shading. Reflectance maps for surface orientation analysis. Estimation of albedo for separating material properties from lighting.
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**List of text books/references**	● D. A. Forsyth and J. Ponce, ● Computer Vision: A Modern Approach, Pearson Education, 2003. ● Richard Szeliski, ● Computer Vision: Algorithms and Applications, Springer-Verlag London Limited, 2011.

1	**Code of the subject**	ES013
2	**Title of the subject**	Business Statistics and Industrial Applications
3	**Any prerequisite**	Basic understanding of descriptive statistics, probability, and data analysis techniques
4	**L-T-P**	3-1-0
5	**Learning Objectives**	● Learn the fundamentals of business statistics, focusing on the application of statistical methods in real-world workplace scenarios. ● Understand core techniques for gathering, analyzing, and interpreting data to support informed decision-making. ● Apply statistical tools and concepts to solve business problems and derive actionable insights from data.
6	**Brief Contents**	Introduction to Statistics and Data Presentation: Introduction to statistics, Data collection methods, Presenting data in tables and graphical formats, Numerical descriptive measures (mean, median, mode, variance, etc.), basic probability concepts and rules; Probability Distributions and Sampling: Discrete probability distributions (Binomial, Poisson), Continuous probability distributions (Normal, Exponential), Sampling methods and sampling distributions, Central Limit Theorem and its applications; Estimation and Hypothesis Testing: Confidence interval estimation (mean, proportion, variance), One-sample hypothesis testing, Two-

		sample tests for means, proportions, and variance, Interpretation of p-values and significance levels; Advanced Statistical Inference: Analysis of Variance (ANOVA), Chi-Square tests (goodness-of-fit, test of independence), Assumptions and applications in real-world data analysis; Regression Analysis: Simple linear regression: model, estimation, and interpretation, Multiple regression basics, Model assumptions, multicollinearity, and residual analysis
7	**Contents for lab**	NA
8	**List of text books/references**	• **Paul Newbold, William L. Carlson, and Betty Thorne,** *Statistics for Business and Economics,* Pearson. • **David M. Levine, Kathryn A. Szabat, and David F. Stephan,** *Business Statistics: A First Course,* Pearson.

1	**Code of the subject**	ES014
2	**Title of the subject**	Robotics
3	**Any prerequisite**	None
4	**L-T-P**	3-0-2
5	**Learning Objectives**	The coursework will be helpful for the students to understand the basic principles of robotics. They will learn about the components, modelling, and basic operations of the robots.
6	**Brief Contents**	Systems Overview of a Robot, Mechanical Systems, Components, Dynamics and Modelling, Control of Actuators in Robotic Mechanisms, Robotic Sensory Devices. Performance Definition - Accuracy/ Repeatability/ Precision with respect to Position &Path, payload, speed, acceleration, cycle time Challenges/applications and uses of Mobile and other robots: wheeled, tracked, legged, aerial, underwater robots, surgical robots, rehabilitation robots, humanoid robots. Introduction to robot manipulation. Forward and inverse kinematics of robots and some case studies. Manipulator dynamics. Basics of robot control. Task planning with emphasis on computational geometry methods for robot path finding, robot arm reachability, grasp planning, etc. Overview of robot vision; Robot Motion Planning
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications

8	**List of text books/references**	1. Francis N. Nagy, Andrassiegler, Engineering Foundation of Robotics, Prentice Hall Inc 2. P.A. Janaki Raman, Robotics and Image Processing An Introduction, Tata Mc Graw Hill Publishing Company Ltd.

1	**Code of the subject**	**ES015**
2	**Title of the subject**	Dynamical System
3	**Any prerequisite**	None
4	**L-T-P**	**3-0-0**
5	**Learning Objectives of the subject**	Understand and differentiate between the fundamental concepts of dynamical systems, including discrete and continuous types, and be able to formulate mathematical models for such systems across physics, biology, and engineering. Analyze the stability of both linear and nonlinear autonomous systems by determining equilibrium points, applying linear stability analysis (including the Hartman-Grobman theorem), and identifying complex behaviors such as limit cycles and attractors (e.g., using the Poincaré-Bendixson theorem). Identify and classify local bifurcations (e.g., saddle-node, pitchfork, Hopf) as parameters change, and explore advanced topics like chaos, strange attractors (Lorenz system), Lyapunov exponents, and basic concepts of control systems (controllability and feedback).
6	**Brief Contents (module wise)**	Definition of dynamical system, Discrete and continuous systems, Formulation of dynamical, system models in physics, biology and engineering, Existence and uniqueness theorems. Introduction tolinear systems, Phase space and trajectories. Autonomous and non-autonomous systems, Stability of systems: Equilibrium points, Stability of linear autonomous systems. Stability of nonlinear systems, Linear stability analysis and Hartman-Grobman theorem, attractors, limit cycles, Poincare-Bendixson theorem, relaxation oscillations. Elements of bifurcation theory: saddle-node, transcritical, pitchfork, Hopf bifurcations, Hopf bifurcation and its applications in real world, Global bifurcations and homoclinic orbits. Chaos and Strange Attractors: Lorenz system, chaos & its measures, Lyapunov exponents, strange attractors, simple maps, period-doubling bifurcations, Feigenbaum constants, fractals. Introduction to control systems, Controllability of autonomous systems, Controllability of non- autonomous systems, feedback and optimal control theory.

7	**Contents for lab**	NA
8	**List of text books/references**	1. S. Strogatz, Nonlinear Dynamics and Chaos: with Applications to physics, Biology, Chemistry, and Engineering, Westview, 1994. 2. S. Wiggins, Introduction to applied nonlinear dynamics & chaos, Springer-Verlag, 2003.

1	**Code of the subject**	ES016
2	**Title of the subject**	Computational Linear Algebra
3	**Any prerequisite**	Engineering Mathematics
4	**L-T-P**	**3-1-0**
5	**Learning Objectives of the subject (in about 50 words)**	By the end of this course, students will be able to apply computational linear algebra techniques to solve complex machine learning problems, understand and implement matrix decompositions, perform dimensionality reduction using PCA, and utilize orthogonality and least-squares methods in data analysis, ensuring a strong mathematical foundation for advanced machine learning applications.
6	**Brief Contents (module wise)**	**Vector Spaces**: Vector spaces and subspaces, Linear dependent and independent vectors, Coordinate system, Basis and dimension, vector transformations, Change of basis. **Orthogonality and least-squares**: Inner products, length and orthogonality, orthogonal sets, orthogonal projections, The Gram-Schmidt process, least-square problems, machine learning and linear models, Inner product spaces and it's applications. **Symmetric Matrices and Quadratic Forms**: Diagonalization of symmetric matrices, spectral theorem, principal axes theorem and quadratic and canonical forms, Positive Definite Matrices, constrained optimization. **Principal Component Analysis**: Eigenvalues and Eigenvectors, Singular Value Decomposition and it's applications, Condition number, Principal components, principal component analysis (PCA), Reduction of multivariate data. Factor analysis for data science and machine learning.
7	**Contents for lab**	NA
8	**List of text books/references**	1. David C. Lay, Steven R. Lay, Judi J. McDonald. Linear Algebra and It's Applications. 6th Edition, Pearson Education Limited 2. Strang, G. (2022). *Introduction to linear algebra*. Wellesley-Cambridge Press. 3. Holfman K and Kunze R. Linear Algebra, Pearson India.

1	**Code of the subject**	ES017
2	**Title of the subject**	Computational Fluid dynamics

3	**Any prerequisite**	None
4	**L-T-P**	3-0-0
5	**Learning Objectives**	Formulate and classify the fundamental governing equations of fluid flow (e.g., Navier-Stokes) in their convective and conservative forms, and identify appropriate initial and boundary conditions based on the mathematical type (parabolic, elliptic, or hyperbolic) of the Partial Differential Equation (PDE). Apply and analyze the stability, consistency, and convergence of major spatial and temporal discretization techniques used in CFD, specifically the Finite Difference (FDM), Finite Volume (FVM), and Finite Element (FEM) methods, including explicit and implicit time integration schemes. Implement and explain the Pressure-Velocity Coupling challenge for incompressible flow and the steps of the SIMPLEC algorithm (and its variants), while also recognizing the role of High-Performance Computing (HPC) using paradigms like MPI and OpenMP for large-scale CFD simulations.
6	**Brief Contents**	Introduction to Fluid Dynamics: Overview of CFD and its applications. Mathematical Formulation of Fluid Flow: Mass, momentum, and energy conservation equations, Navier-Stokes equations and simplifications. Convective and conservative forms of governing equations. Classification to governing equations: Classification of PDEs: Parabolic, Elliptic, Hyperbolic Equations; initial and boundary conditions in CFD. Introduction to numerical methods: Time Integration Methods: Explicit vs. Implicit schemes, Time-stepping methods (Euler, Runge-Kutta, Crank- Nicholson). Spatial Discretization Methods: Finite Difference Method (FDM): Discretization techniques, Stability, consistency, and convergence analysis. Finite Volume Method (FVM): Control volume approach, Flux-based formulations. Finite Element Method (FEM): Weighted residual methods, Shape functions and element matrices, Application of FEM in incompressible flows. Pressure-Velocity Coupling: Challenges in solving incompressible Navier-Stokes equations. SIMPLE (Semi-Implicit Method for Pressure-Linked Equations) algorithm: Step-by-step derivation and implementation: Variants: SIMPLEC, SIMPLER. High-Performance Computing (HPC) in CFD: Parallel Computing Concepts: Introduction to Message Passing Interface (MPI), Shared vs. distributed memory parallelism (OpenMP and MPI), Load balancing in large-scale CFD simulations.
7	**Contents for lab**	NA
8	**Text /references**	1. S. V. Patankar , Numerical Heat Transfer and Fluid Flow. 3. T. J. Chung, Computational Fluid Dynamics.

1	**Code of the subject**	**ES018**
2	**Title of the subject**	Approximation and Estimation theory
3	**Any prerequisite**	None
4	**L-T-P**	**3-0-0**
5	**Learning Objectives of the subject**	Master classical and modern interpolation techniques (e.g., Lagrange, Newton's, and spline interpolation) and apply various approximation methods, including those based on convolution and positive definite functions, to construct functional representations. Understand the fundamental concepts of best approximation in normed spaces, including the significance of the Weierstrass Theorem, the role of Bernstein polynomials and Korovkin's theorem, and the application of Chebyshev polynomials in achieving linear best and least squares approximations. Analyze the theoretical limits and convergence of approximation schemes using results like Bernstein's inequality and Jackson's theorems, and explore advanced topics such as approximation via Fourier series, properties of positive linear operators. -approximation, and the use of radial basis functions and ridge functions (relevant to Gaussian processes and neural networks).
6	**Brief Contents (module wise)**	**I**nfinite Series, Interpolation (Lagrange interpolation, Newton's interpolation, spline interpolation, etc.), Approximation by convolution and positive definite functions. Introduction to approximations theory, best approximations in Normed Spaces, Weierstrass Theorem, Bernstein's polynomials, Korovkin theorem, spline approximation of smooth functions in 1D, Polynomial and trigonometric approximation of analytic functions in 1D, linear best approximation, best n term approximation, least square approximations. Properties of the Chebyshev Polynomials. Bernstein's inequality, Jackson's theorems. Approximation by means of Fourier series. Positive linear operators, Monotone operators, Simultaneous approximation, *Lp*-approximation. Approximation of analytic functions, radial basis functions and Gaussian processes, ridge functions and neural networks.
7	**Contents for lab**	NA
8	**List of text books/references**	Functional Analysis: A First Course, Thamban Nair Approximation Theory and Methods, M. J. D. Powell Approximation Theory and Approximation Practice, N. Trefethen

1	**Code of the subject**	ES207
2	**Title of the subject**	Computer Networks
3	**Prerequisite**	User applications and some aspects of process and their interaction
4	**L-T-P**	3-0-2
5	**Learning Objectives**	To understand the purpose and overview of the Internetworking technology, issues, and approaches using top-down philosophy.
6	**Brief Contents**	**Chapter I** Computer Networks and the Internet A Nuts-and-Bolts Description of Internet, A Services Description, The Network Edge, Client and Server Programs, The Network Core, ISPs and Internet Backbones, Performance in Packet-Switched Networks, Protocol Layers and Their Service Models, The Development of Packet Switching, Proprietary Networks and Internetworking, The Internet Explosion, Recent Developments. **Chapter II** Application Layer Network Application Architectures, Processes Communication, Transport Services, Transport Services, Application-Layer Protocols, The Web and HTTP, User-Server Interaction: Cookies, Web Caching, Peer-to-Peer Applications, P2P File Distribution, Searching for Information in a P2P Community, Case Study: P2P Internet Telephony with Skype, Socket Programming with TCP and UDP **Chapter III** Transport Layer Relationship Between Transport and Network Layers, Overview of the Transport Layer in the Internet, Principles of Reliable Data Transfer, Building a Reliable Data Transfer Protocol, Pipelined Reliable Data Transfer Protocols, Round-Trip Time Estimation and Timeout, Principles of Congestion Control, The Causes and the Costs of Congestion, Approaches to Congestion Control, TCP Congestion Control, Fairness. **Chapter IV** The Network Layer Network Service Models, Datagram Networks, Router architecture: Input Ports, Switching, Output Ports, Queuing. The Internet Protocol (IP),IP Security VPNs, Routing, Broadcast and Multicast Routing. **Chapter V** The Link Layer and Local Area Networks Link Layer Services, Multiple Access protocols, Link-Layer Addressing, Ethernet, Link-Layer, PPP: The Point-to-Point Protocol, Link Virtualization. **Chapter VI** Wireless and Mobile Networks Wireless Links and Network Characteristics, WiFi: 802.11 Wireless LANs, Beyond 802.11: Bluetooth and WiMax, Cellular Internet Access, Mobile IP.
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**Text /references**	Computer Networking: A top-down approach featuring the Internet / James F. Kurose , Keith W. Ross., 8th edition, Pearson.

1	**Code of the subject**	ES019
2	**Title of the subject**	Microprocessor and Interfacing
3	**Any prerequisite**	Digital Electronics
4	**L-T-P**	3-0-2
5	**Learning Objectives**	Upon completion of this course, the student will be able to: ● To develop background knowledge and core expertise in microprocessor. ● To study the concepts and basic architecture of 8085, and 8086 processor. ● To know the importance of different peripheral devices and their interfacing to 8086. ● To know the design aspects of basic microprocessor. ● To write assembly language programs in microprocessor for various application
6	**Brief Contents**	Microprocessors-Evolution and Introduction, Microprocessor based system, Origin of Microprocessor, Classification of Microprocessors, Types of Memory, I/O Devices, Technology Improvements Adapted to Microprocessors and Computers, Introduction to 8085 processor, Architecture of 8085, Microprocessor instructions, classification of instructions, Instruction set of 8085, Basic 80x86 Architecture, Role of Microprocessor in Micro Computer, Features of 8086, Internal Block Diagram of 8086, Execution Unit, Bus Interface Unit, Programming of x86 processor, Interrupt mechanism of x86 & Interfacing of chips, Advanced Processor Technologies Interfacing of Data Converters (D-To-A and A-To-D), Programmable Interfacing Devices Like 8255A PPI, 8253/8254 Timer, 8259A PIT, Serial I/O Concepts, SID And SOD, 8251A USART. Interfacing of above chips with 8085.
7	**Contents for lab**	Assembly language programs for 8085 and 8086, Programs involving Arithmetic & logical operations, Programs involving data transfer instructions, programs involving bit manipulation instructions, programs involving branch/ loop instructions, Interfacing Experiments.
8	**List of text books/references**	● Microprocessors and Interfacing by Douglas V. Hall ● The 8051 Microcontroller and Embedded Systems by M.A. Mazidi and J. G. Mazidi, PHI. ● The Intel Microprocessors by Barry B. Brey, Prentice Hall. ● The 8088 and 8086 Microprocessors by Walter A. Triebel, Avtar Singh, Prentice Hall Inc. ● 8086/8088 family: Design, Programming and Interfacing by John Uffenbeck, Prentice Hall. ● Advanced Microprocessor and Peripherals, Architecture Programming and Interfacing by A. K. Ray and K. M. Burchandi, Tata McGraw Hill. ● Microcontroller and Embedded Systems by M. A. Mazidi, Pearson Education. ● 8051 Microcontroller and Embedded Systems by R. Kapadia, Jaico Publishing House.

		● Fundamentals of Microprocessors and Microcomputers by B. Ram, Dhanpat Rai Publications.

1	**Code of the subject**	ES020
2	**Title of the subject**	Software Defined Systems
3	**Prerequisite**	Basic knowledge of operating systems, computer networks, and programming
4	**L-T-P**	3-0-0
5	**Learning Objectives**	To introduce the foundational principles of Software-Defined Systems. To explore key domains including Software-Defined Networking (SDN), Storage (SDS), and Computing (SDC). To understand the architecture, virtualization, and orchestration techniques in SDS.
6	**Brief Contents**	I ntroduction to Software-Defined Systems: Definition, evolution, and motivations; abstraction and decoupling; system-level programmability; key domains (SDN, SDS, SDC, SDI); benefits and challenges. Software-Defined Networking (SDN): Overview of SDN architecture, separation of control and data planes, OpenFlow protocol, SDN controllers, network programmability, use cases in cloud and HPC. Software-Defined Storage (SDS): Concept of SDS, storage virtualization, data abstraction and pooling, distributed file systems, policy-based provisioning, integration with cloud storage systems. Software-Defined Computing (SDC) Virtualization of compute resources, hypervisors and containerization (e.g., KVM, Docker), orchestration tools (e.g., Kubernetes), dynamic resource allocation, autoscaling. Software-Defined Infrastructure (SDI) and Orchestration Integrated view of SDN, SDS, and SDC; infrastructure as code; orchestration platforms (e.g., OpenStack); automation using Ansible, Terraform; monitoring and analytics.
7	**Contents for lab**	NA
8	**Text /references**	“Software-Defined Data Centers with VMware” by John A. Davis, Steve Baca, and Owen Thomas, VMWare Press, 2014. “SDN: Software Defined Networks” by Thomas D. Nadeau and Ken Gray, O’Reilly Media, 2013. “Software Defined Infrastructure” by Abhijit Chavan, CreateSpace Independent Publishing Platform, 2017.

1	**Code of the subject**	ES021
2	**Title of the subject**	Cyber Physical Systems
3	**Prerequisite**	Basic knowledge of networking, control systems, linear algebra
4	**L-T-P**	3-0-0
5	**Learning Objectives**	● To understand the architecture and dynamics of CPS. ● To model and analyze CPS using mathematical and computational techniques. ● To explore the interaction between discrete and continuous components in hybrid systems.
6	**Brief Contents**	Introduction to CPS: Definition, motivation, key examples (autonomous systems, smart energy, medical CPS), components of CPS, design challenges, cyber-physical feedback. Modeling of CPS: Continuous-time and discrete-time models, hybrid systems, state-space representation, finite state machines, Petri nets, transition systems. Control in CPS: Embedded control systems, feedback design, PID and state-space control, stability analysis, real-time constraints, time-triggered and event-triggered control. Communication and Networking in CPS: Network-induced delays, packet loss, sampling and quantization, NCS (Networked Control Systems), distributed architectures. Verification and Formal Methods: Safety, liveness, reachability, temporal logic, model checking, bounded verification, tools like UPPAAL, HyTech, and SpaceEx. Case Studies and Applications: Autonomous vehicles, medical devices, smart grids, UAV systems, building automation, embedded real-time simulation (e.g., with Simulink, ROS).
7	**Text /references**	"Introduction to Embedded Systems: A Cyber-Physical Systems Approach" by Edward A. Lee and Sanjit A. Seshia, MIT Press, 2nd Ed. "Principles of Cyber-Physical Systems" by Rajeev Alur, MIT Press, 2015. "Cyber-Physical Systems: Foundations, Principles and Applications" by Houbing Song et al., Elsevier, 2016.

1	**Code of the subject**	ES022
2	**Title of the subject**	Cloud Computing Technologies
3	**Any prerequisite**	Basic understanding of computer system
4	**Will this course require visiting faculty**	None
5	**L-T-P**	3-0-0

6	**Learning Objectives of the subject (in about 50 words)**	Upon course completion, students will be able to: 1. Understand the basic concepts and architecture of Cloud computing. 2. Implement Cloud Services through AWS offerings and Restful web services. 3. Apply the knowledge of virtualization through different virtualization technologies.. 4. Perform operations on data sets using Map Reduce framework, SQL and NO SQL databases
7	**Brief Contents (module wise)**	**Module-I: Introduction and Evolution of Computing Paradigms:** General Benefits and Architecture, Business Drivers, Main players in the Field, Overview of Existing Hosting Platforms and its architecture, Cluster Computing, Grid Computing, XaaS Cloud Based Service Offerings, Overview of Security Issues. **Module-II: Classification of Cloud Implementations:** Key Amazon offerings-Amazon Web Services, The Elastic Compute Cloud (EC2), Simple Storage Service (S3), Simple Queuing Services (SQS), Bundling Amazon instances, AWS Identity Management and Security in the Cloud, Messaging in the Cloud, RESTFul Web Services. **Module-III: Virtualization:** Virtualization, Advantages and disadvantages of Virtualization, Types of Virtualization: Resource Virtualization i.e. Server, Storage and Network virtualization, Migration of processes, Classic Data Center, Virtualized Data Center (Compute, Storage, Networking and Application), Business Continuity in VDC. VMware vCloud – IaaS, Network virtualization through Software Defined Networks, data centre energy consumption; Green data centres design, cooling, and energy management; Virtualization and server consolidation; **Module-IV: Cloud based Data Storage:** Introduction to Hadoop, Hadoop Ecosystem (Pig, Hive, Cassandra and Spark), Introduction No-SQL databases, Map- Reduce framework for Simplified data processing on Large clusters using Hadoop, Data Replication, Shared access to data stores. **Module-V: Related Technologies:** Introduction to Fog Computing and Edge Computing, Usage of Cloud for IoT and Big data analytics, Overview of Google AppEngine - PaaS, Microsoft Azure, Orchestration, Containers, and Kubernetes.
7	**Contents for lab**	
8	**Text /references**	● Cloud Computing: Principles and Paradigms, Editors: RajkumarBuyya, James Broberg, Andrzej M. Goscinski, Wiley ● Kai Hwang, Geoffrey Fox and Jack Dongarra, Distributed and Cloud Computing: From Parallel

		Processing to the Internet of Things, Morgan Kaufmann ● Enterprise Cloud Computing - Technology, Architecture, Applications, Gautam Shroff, Cambridge University Press ● Cloud Computing Bible, Barrie Sosinsky, Wiley-India ● Cloud Security: A Comprehensive Guide to Secure Cloud Computing, Ronald L. Krutz, Russell Dean Vines, Wiley

1	**Code of the subject**	ES023
2	**Title of the subject**	Immersive Technologies: AR & VR Applications
3	**Any prerequisite**	Basic understanding of computer system
4	**Will this course require visiting faculty**	None
5	**L-T-P**	3-0-2
6	**Learning Objectives of the subject**	On completion of this course, the students will be able to 1. Analyze the components of AR systems, its current and upcoming trends, types, platforms, and devices. 2. Understand the basic steps and technologies required to achieve AR system. 3. Apply various well-known computer vision algorithms in order to implement the AR. 4. Understand the various components, applications, latest devices and working model of VR systems. 5. Develop interactive augmented and virtual reality applications for PC and Mobile based devices using a variety of input devices.
7	**Brief Contents (module wise)**	**Module 1: Introduction of Augmented Reality (AR):** Definition and Applications, History, Types of AR, Suitable devices, Holograms, Mixed reality, Ubiquitous computing, AR Displays: Method of Augmentation, Spatial Display Model. **Module 2: Tracking in AR:** Basic steps of AR, Tracking, Occlusion, Calibration, Registration, Co-ordinate Systems: Model-View-Projective Transformation, Frame of reference, Characteristics of Tracking Technology: Physical Phenomenon, Triangulation, Trilateration, Measurement Principles, Degree of Freedom, Stationary Tracking System, Mobile Tracking, Optical Tracking, Sensor Fusion. **Module 3: Computer Vision for AR:** Marker Tracking, Thresholding, Contour detection, Hough Transformation, Quadrilateral fitting, SIFT, Pose Estimation, Homography, Incremental Tracking, SLAM: Bundle Adjustment, Parallel Tracking and Mapping, Outdoor Tracking, STML. **Module 4: Virtual Reality:** Definition, History, Application, Types of VR, Components of VR,VR- HMDs and their working, Geometric modeling, Modeling Transformation, Viewing transformation Chain and Rendering Pipeline, Light and Optical

		System, Rendering Problems in VR, Shading Models, Rasterization, Depth, Motion and Auditory Perception, Rendering, Post Rendering Image Warping, AR/VR for interactive and immersive applications in STEM
8	**Contents for lab (If applicable)**	● To implement various techniques studied during the course.
8	**Text /references**	● Dieter Schmalstieg, Tobias Höllerer, Augmented-Reality-Principles-and-Practice-Usability- , Addison-Wesley (2016) 1st ed. ● Parisi T., Learning Virtual Reality, O'Reilly (2016)1st ed. ● Gerard Jounghyun Kim, Designing Virtual Reality Systems: The Structured Approach, Springer (2005) 1st ed.

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1	**Code of the subject**	IT101
2	**Title of the subject**	Principles of Computer Programming
3	**Prerequisite**	No
4	**L-T-P**	3-0-2
5	**Learning Objectives**	To understand the basic principles of programming languages. To provide design & development of C and Python programming skills. To introduce problem solving methods and program development.
6	**Brief Contents**	Basics of Computer Languages C, Compilers, Interpreter, Programming Environments and Debugging: types of errors and debugging techniques. Programming features: Data types, Expressions and Operators, Control statements, Iterations. Functions: Scope of variables, call by value, call by reference, Recursion, Pointers. Array, String, Structures and Unions. File handling, File redirection, File pointers. Applications of C programming concepts in different data structures. Python: Introduction, Program Organization, Functions, Modules and Libraries.
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**Text/references**	1. Kernighan, B.W. and D. M. Ritchie (1998): The C programming language, 2nd ed. Prentice Hall of India. 2. Kanetkar, Y (2016): Let us C, 15th ed . BPB Publications. 3. King K.N (2008): C Programming: A Modern Approach. 2nd ed. W. W. Norton & Company.

1	**Code of the subject**	IT102
2	**Title of the subject**	Data Structures
3	**Any prerequisite**	Basic Computer Programming
4	**L-T-P**	3-0-2
5	**Learning Objectives**	To enable students to learn how to store data while maintaining the data correctness and efficiency in a computer program.
6	**Brief Contents**	Objected oriented programming, List, Sequence, Stack Queue, Program correctness and analysis, Dictionaries, Searching, Trees, traversals, binary search trees, optimal and average BSTs. Balanced BST: AVL Trees, 2-4 trees, red-black trees, B-trees. Sorting, Graphs and Traversal, Graphs algorithms, Geometric data structures, etc.
7	**Contents for lab**	Experiments will be conducted based on the topics covered.
8	**List of text books/references**	1. Data Structures and Algorithm Analysis in C++, by Mark Allen Weiss (Pearson 2007). 2. Goodrich, M. and Tamassia, R. *Data Structures and Algorithms in Java* , John Wiley and Sons, Inc. 3. Fundamentals of Data Structures in C -- by Horowitz, Sahni and Anderson-Freed (Silicon Press 2007).

		4. Data Structure Using C and C++ -- by Y. Langsam, M. J. Augenstein and A. N. Tanenbaum (Pearson Education, 2nd Edition, 2015).

1	**Code of the subject**	IT103
2	**Title of the subject**	Object Oriented Programming
3	**Prerequisite**	Programming concepts
4	**L-T-P**	3-0-2
5	**Learning Objectives**	To develop programming skill and to solve engineering related problems using Object Oriented Programming Concepts.
6	**Brief Contents**	Object oriented thinking: Need for OOP Paradigm, Procedural programming vs object oriented programming, object oriented concepts. Class and object concepts: Difference between C structure and class, specifying a class, Defining members inside and outside class, etc. Constructor and destructor concepts, Operator overloading and Type Conversion, Inheritance and polymorphism concepts Working with files: Classes for file stream operations, opening and closing files, File opening modes, file Pointers, Error handling during file operations, command line arguments. Templates: Class template, class template with parameter, function template, function template with parameter and Exception handling
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**List of text books/references**	1. HM Deitel and PJ Deitel ―C++ How to Program, Seventh Edition, 2010, Prentice Hall. 2. Brian W. Kernighan and Dennis M. Ritchie, ―The C programming Language, 2006, Prentice-Hall. 3. E Balagurusamy, ―Object oriented Programming with C++, Third edition, 2006, Tata McGraw Hill. 4. Bjarne Stroustrup, ―The C++ Programming language, Third edition, Pearson Education. 5. Horstmann ―Computing Concepts with C++ Essentials, Third Edition, 2003, John Wiley. 6. Robert Lafore, ―Object Oriented Programming in C++, 2002, Pearson education.

1	**Code of the subject**	IT201
2	**Title of the subject**	Discrete Structures
3	**Prerequisite**	Engineering Mathematics
4	**L-T-P**	3-1-0

5	**Learning Objectives**	To prepare for a background in abstraction, notation, and critical thinking for the mathematics most directly related to computer science. To foster rigorous thinking skills that can enhance the quality of work of computing professionals. To relate and apply these concepts to practical applications of computer science.
6	**Brief Contents**	Fundamentals of Logicand their use in program proving, resolution principle. Set Theory and Functions, Graph Theory, Group Theory, Elementary Combinatorics etc.
7	**Text/references**	1. Bernanrd Kolman, Robert C Busby, S. Ross, Discrete Mathematical Structures, PHI Learning 2. Kenneth H. Rosen, Discrete Mathematics and Its Applications, Tata McGraw-Hill Edition 3. I.N. Herstein, Topics in Algebra, John Wiley Publications 4. Ralph P. Grimaldi, B.V. Ramana, Discrete and Combinatorial Mathematics, Pearson Education

1	**Code of the subject**	IT202
2	**Title of the subject**	Computer Organisation and Architecture
3	**Any prerequisite**	Digital Electronics, Principles of computer programming
4	**L-T-P**	3-0-2
5	**Learning Objectives**	To understand the Organization and architecture aspects of computer followed by the Application Binary Interfaces.
6	**Brief Contents**	Basic functional blocks of a computer, introduction to Instruction set architecture of a CPU and instruction sets of some common CPUs. Data representation, Computer arithmetic, Control unit design, Memory system, Peripheral devices and their characteristics, Performance enhancement techniques Pipelining, Memory organization.
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**Text/references**	1. Computer Organization and Design: The Hardware/Software Interface, David A Patterson, John L. Hennessy, 4th Edition, Morgan Kaufmann. 2. Computer Architecture and Organization by William Stallings, PHI Pvt. Ltd., Eastern Economy Edition.

1	**Code of the subject**	IT203
2	**Title of the subject**	Design and Analysis of Algorithms
3	**Prerequisite**	Data Structures, Principles of Computer Programming, Engineering Mathematics
4	**L-T-P**	3-0-2

5	**Learning Objectives**	To understand the performance aspects of algorithms in programming the computing systems
6	**Brief Contents**	Introduction, Asymptotic complexity, Searching in list, Concepts of graphs and shortest path estimation algorithms, Divide and conquer approaches, Search Trees, Greedy : Interval scheduling, Greedy :Proofstrategies,Greedy : Human coding, Dynamic Programming: weighted interval scheduling Dynamic Programming, Intractability: NP completeness, Intractability :reductions and examples
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**Text/references**	1. Introduction to Algorithms (Eastern Economy Edition) by Thomas H Cormen and Charles E Leiserson. 2. Design and Analysis of Algorithms by S Sridhar. 3. Design and Analysis of Computer Algorithms by AHO.

1	**Code of the subject**	IT204
2	**Title of the subject**	Data Communication
3	**Any prerequisite**	NA
4	**L-T-P**	3-0-2
7	**Learning Objectives**	To enable understand the fundamentals of data communication systems and network models.
8	**Brief Contents**	Introduction and Network Models: Introduction to Data Communication • Components of Data Communication • Data Flow, Transmission Modes • Protocols and Standards • OSI and TCP/IP Models • Network Devices: Repeater, Hub, Bridge, Switch, Router, Gateway Physical Layer and Signal Transmission: Data and Signals: Analog vs Digital, Bit rate vs Baud rate • Transmission Impairments • Digital Transmission: Line Coding, Block Coding, Scrambling • Analog Transmission: Modulation techniques (ASK, FSK, PSK, QAM) 10 • Bandwidth Utilization: Multiplexing (FDM, TDM, WDM), Spreading (FHSS, DSSS) Transmission Media and Switching : Guided Media: Twisted Pair, Coaxial, Optical Fiber • Unguided Media: Radio, Microwave, Infrared • Circuit-Switched, Packet-Switched, and Message-Switched Networks • Telephone and Cable Network Transmission for Data Data Link Layer: The Data Link Layer: Introduction, Services, • Error Detection and Correction Techniques (Parity, CRC, Hamming Code) • Flow and Error Control Mechanisms • Protocols: Stop-and-Wait, Go-Back-N, Selective Repeat • Multiple Access Protocols (ALOHA, CSMA, CSMA/CD, CSMA/CA) • Wired and Wireless

		LANs: Ethernet, IEEE 802.11 (Wi-Fi) • LAN Devices and Topologies Backbone and WAN Technologies: - Internetworking Devices and Virtual LANs • - Cellular Networks and Satellite Communication • - SONET/SDH Architecture • - Virtual Circuit Networks: Frame Relay and ATM
9	**Contents for lab**	Experiments will be based on the theory covered as above.
10	**List of text books/references**	1. B. A. Fourozan, "Data Communications and Networking", 4th Edition, Singapore, McGrawHill, 2004. 2. James F. Kurose, Keith W. Ross, "Computer Networking: A Top-Down Approach Featuring the Internet", 3rd Edition, Pearson Education 2009 3. William Stallings, "Data and Computer Communications", Seventh Edition, PHI 2004. 4. Andrew S. Tanenbaum,"Computer Networks" 4th Edition PHI 2004

1	**Code of the subject**	IT205
2	**Title of the subject**	Database Systems
3	**Prerequisite**	No
4	**L-T-P**	3-0-2
5	**Learning Objectives**	To understand a Database application, the design and performance aspects from the perspective of Database systems of the past, present and future.
6	**Brief Contents**	Introduction to Databases, Relational Data Model, Relational Algebra, SQL and NoSQL concepts, Database Normalization, Indexing, Database Transactions, Recovery Systems, Transaction Schedules, Concurrency Control, Query Processing and Query Optimization.
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**Text /references**	1. Abraham Silberschatz, Henry Korth, and S. Sudarshan. Database Systems Concepts (5ed.). McGraw-Hill, New York, USA. 2. Ramez A. Elmasri, Shankrant B. Navathe. Fundamentals of Database Systems Addison-Wesley Longman Publishing Co. 3. Paul DuBois. Mysql. New Riders Publishing 4. C. J. Date. Database in Depth: Relational Theory for Practitioners. O'Reilly Media, Inc. 5. Bipin C. Desai. An Introduction to Database Systems. West Publishing Co.

1	**Code of the subject**	IT206
2	**Title of the subject**	Theory of Computation
3	**Prerequisite**	No

4	**L-T-P**	3-0-0
5	**Learning Objectives**	To introduce the mathematical foundations of computation, develop the ability to understand and conduct mathematical proofs for computation and algorithms.
6	**Brief Contents**	Finite Automata, Finite State system concepts, Regular Languages, Equivalence of NFA and DFA, Minimization of DFA- – Pumping Lemma for Regular. Grammars, Pushdown Automata, Turing Machines, Unsolvable Problems and Computable functions, Measuring and classifying complexity: Tractable and Intractable problems- Tractable and possibly intractable problems – P and NP completeness – Polynomial time reductions.
7	**Text /references**	1. Hopcroft J.E., Motwani R. and Ullman J.D, Introduction to Automata Theory, Languages and Computations, Pearson Education. 2. John C Martin, Introduction to Languages and the Theory of Computation, TMH, New Delhi.

1	**Code of the subject**	IT207
2	**Title of the subject**	Operating Systems
3	**Prerequisite**	Computer Organization; Data Structures and Computer Programming
4	**L-T-P**	3-0-2
5	**Learning Objectives**	To study the importance of the operating system and its function, techniques of the operating system to achieve its goals as resource manager. Application interaction with the operating system and the operating systems interaction with the machine.
6	**Brief Contents**	Introduction and history of Operating systems, Process concepts and scheduling, Storage management, Processor management, Inter process communication, CPU scheduling, Process Synchronization, Memory Management, Virtual memory concepts, Deadlocks, Device management, File management, File Systems, Free space Management: Bit vector, Linked list. Some case Studies of traditional and modern operating systems.
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**Text /references**	1. A. Silberschatz & P.B. Galvin, Operating System concepts and principles, Wiley India. 2. A. Tanenbaum, Modern Operating Systems‘, Prentice Hall India 3. W. Stallings, _Operating Systems: Internals and design Principles, Pearson Ed. 4. M.J. Bach, Design of Unix Operating system‘, Prentice Hall. Additional Reading: 1. D.M. Dhamdere, Operating Systems: a concept based approach‘, Tata McGraw-Hill Pubs. 2. G. Glass, Unix for programmers and users-a complete guide, Pearson Ed.

1	**Code of the subject**	IT208
2	**Title of the subject**	Computer Networks
3	**Prerequisite**	User applications and some aspects of process and their interaction
4	**L-T-P**	3-0-2
5	**Learning Objectives**	The understand the purpose and overview of the Internetworking technology, issues, and approaches using top-down philosophy.
6	**Brief Contents**	Computer Networks and the Internet, Network Application Architectures, Processes Communication, Transport Services, Application-Layer Protocols, The Web and HTTP, Case Study: P2P Internet Telephony with Skype, Socket Programming with TCP and UDP; Transport Layer: Relationship Between Transport and Network Layers, Overview of the Transport Layer in the Internet, Principles of Reliable Data Transfer Services, Multiple Access protocols, Link-Layer concepts; Wireless and Mobile Networks, Cellular Internet Access, Mobile IP.
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**Text /references**	Computer Networking: A top-down approach featuring the Internet / James F. Kurose , Keith W. Ross., 7th edition, Pearson.

1	**Code of the subject**	IT209
2	**Title of the subject**	Graph Theory
3	**Any prerequisite**	N/A
4	**L-T-P**	3-0-2
5	**Learning Objectives**	To develop ability to solve real life problems, translating them one form to another, using appropriate mathematical and computational techniques. To prepare abstract and critical mathematical thinking, most directly related to computer science
6	**Brief Contents**	Introduction to graphs, connected graphs and shortest paths, trees, independent set coverings and matchings, vertex colorings, planar graphs, directed graphs, tournaments, spanning tree, cut-set, vector space of a graph, Applications of graph theory.
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**List of text books/references**	1. J.A. Bondy and U.S.R. Murty: Graph Theory and Applications. 2. West, Douglas B., Introduction to Graph Theory, Pearson Education, 2002. 3. Mott J.L., Kandel, A. and Baker T.P., Discrete Mathematics for Computer Scientists and Mathematicians, Prentice Hall of India, 2001.

		4. Reinhard Diestel, Graph Theory, Springer International Edition, 2004. 5. D.B. West: Introduction to Graph Theory, Prentice-Hall of India/Pearson, 2009 6. Deo Narsingh, Graph Theory With Applications To Engineering And Computer Science, PHI, 1992.

1	**Code of the subject**	IT308
2	**Title of the subject**	Nature Inspired Computing
3	**Any prerequisite**	Basic Mathematics, Data Structures, and Algorithms
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	It introduces a new paradigm of computing and solving problems. It has great applications in Artificial Intelligence, Data Mining, Machine Learning, and real-world design and optimization problems.
6	**Brief Contents**	Introduction to Evolutionary Computation: Representation, Initial Population, Fitness Function, Selection, Reproduction Operators, Stopping Conditions, Evolutionary versus Classical Computation; Genetic Algorithm: Canonical Genetic Algorithm, Crossover, Mutation, Control Parameters, Genetic Algorithm Variants, Applications; Differential Evolution, Particle Swarm Optimization, Artificial Bee Colony Algorithm. ANN Introduction, Evolution, McCulloh-Pitts Neuron, Linear Separability, Hebb Network; Perceptron Networks, Adaptive Linear Neuron, Multiple Adaptive Linear Neuron, Back-Propagation Network, Radial Basis Function Network; Associative Memory Network, Heteroassociative Memory Network, Bidirectional Associative Memory, Hopfield Network, Iterative Autoassociative Memory Network, Temporal Associative, Self-organizing maps, Linear Vector Quantization, Counter Propagation Network.
7	**Contents for lab**	N/A
8	**List of text books/references**	1. S N Sivanandam and S N Deepa, Principles of Soft Computing, Wiley India 2. Andries P. Engelbrecht, Computational Intelligence: An Introduction, Jhon Wiley & Sons. 3. S. Rajasekaran and G. A. Vijayalakshmi Pai, Neural Networks, Fuzzy Logic, and Genetic Algorithms: Synthesis and Applications, PHI.

1	**Code of the subject**	IT302
2	**Title of the subject**	Compiler Design
3	**Prerequisite**	Theory of Computation
4	**L-T-P**	3-0-2

5	**Learning Objectives**	To design the front end of the compiler, scanner, parser, intermediate code generator, objectcode generator, and the parallel compilation strategies. To gain the ability to implement a parser etc.
6	**Brief Contents**	The structure of Compiler – Lexical analysis, Syntax analysis, LR parsers; Intermediate code generation concepts, Object code generation, Code optimization, Parallelizing compiler etc.
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**Text /references**	1. Alfred V. Aho, Monica S.Lam, Ravi Sethi, Jeffrey D.Ullman, Compilers : Principles, Techniques and Tools, Second Edition, Pearson Education. 2. Randy Allen, Ken Kennedy, Optimizing Compilers for Modern Architectures: A Dependence-based Approach, Morgan Kaufmann Publishers. 3. Steven S. Muchnick, Advanced Compiler Design and Implementation‖, Morgan Kaufmann Publishers - Elsevier Science, India, Indian Reprint.

1	**Code of the subject**	IT303
2	**Title of the subject**	Computer Graphics
3	**Prerequisite**	
4	**L-T-P**	3-0-2
5	**Learning Objectives**	To expose onto the primary tools by which the flood of information from Computational Science is analyzed.
6	**Brief Contents**	Introduction of computer graphics, Graphic Displays and the algorithms; Three Dimensional aspects of graphics; Transformations; Windowing and Clipping concepts; Hidden Lines and Surfaces etc.
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**List of text books/references**	1.Computer Graphics, C Version Donald D Hearn, M. Pauline Baker 2. Computer Graphics: Principles and Practiceby James D. Foley, Andries van Dam , Steven K. Feiner

1	**Code of the subject**	IT304
2	**Title of the subject**	Trustworthy Artificial Intelligence
3	**Prerequisite**	Algorithms and Data Structures
4	**L-T-P**	3-0-2
5	**Learning Objectives**	To understand the techniques and concepts related to machine based reasoning systems through various applications of AI

6	**Brief Contents**	Introduction to AI and intelligent agents. Problem solving methods in AI, Informed and uninformed search strategies, knowledge representation, Uncertain Knowledge and Reasoning, Probabilities, Bayesian Networks. Overview of different forms of learning, Learning Decision Trees, Artificial Neural Networks and Fuzzy Approaches; Logic in AI, Prolog, Modern AI language and tools etc.
7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**Text /references**	1. S. Russell and P. Norvig, Artificial Intelligence: A Modern Approach, 2nd Ed, Prentice Hall, 2003 2. Elaine Rich and Kevin Knight. Artificial Intelligence, Tata McGraw Hill Reference Books: 1. Patrick Henary Winston, Artificial Intelligence, Pearson publication 2. Deepak Khemani. A First Course in Artificial Intelligence, McGraw Hill Education (India) 3. Eugene Charnaik and Drew McDermott, Introduction to Artificial Intelligence, Pearson publication 4. Nils John Nilsson, The Quest for Artificial Intelligence: A History of Ideas and Achievements, Morgan Kaufman 5. Dennis Rothman, Artificial Intelligence by Example

1	**Code of the subject**	IT305
2	**Title of the subject**	Game Theory
3	**Any prerequisite**	Basic knowledge of Engineering Mathematics and Statistics
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	To learn the applications of game theory, auction and equilibrium.
6	**Brief Contents**	Introduction to Game Theory, Dominant Strategies and Nash Equilibrium, Alternate Strategies: Maximin, Maximax, and Minimax Regret Solvability, N-Player Games, Mixed Strategy, Subgame Perfection in Discrete Choice Games, Continuous Games and Imperfect Competition, Infinitely Repeated Games, Tacit Collusion, Simultaneous-play, Bayesian Games, Applications of Bayesian Games: Auctions and Voting, Cournot‘s Duopoly with Imperfect Information, Radio Spectrum, With Arbitrary Distribution of Valuations, Extensive Form Game with Perfect Information, Stackelberg Model of Duopoly, Buying Votes, Committee Decision-Making, Repeated games, The Prisoner‘s Dilemma, General Result, Supermodular Game and Potential Game, Wireless Networks: Resource Allocations, Admission Control, Routing in Sensor and Ad-Hoc Networks, Modeling Network Traffic and Strategic Network Formation, Rubinstein Bargaining Model with

		Alternating Offers, Nash Bargaining Solution, Multi armed bandit problem.
7	**Contents for lab**	N/A
8	**List of text books/references**	1. Martin Osborne, An Introduction to Game Theory, Oxford University Press, 2003 2. Prajit Dutta, Strategies and Games, MIT Press. 3. K H Ericson, Game Theory, Createspace Independent Publishing Platform.

1	**Code of the subject**	IT306
2	**Title of the subject**	Machine Learning
3	**Any prerequisite**	Introductory courses on probability theory and linear algebra. Knowledge of basic programming languages such as Python and MATLAB.
4	**L-T-P**	3-0-2
5	**Learning Objectives**	After successful completion of this course, students will able to relate/understand/solve several day-to-day real-time with machine learning algorithms. The objective of this course is to familiarize the students with different machine learning algorithms ranging basic linear classifier/regression modeling problems to non-linear classification problems using deep neural network.
6	**Brief Contents**	Introduction to the course of machine learning (ML), Classification, regression, sequence modeling. Linear classifier and classification problem, Gradient descent algorithm, Underfitting vs Over-fitting problem, Training, Testing, and Validation Process, Supervised vs unsupervised classification, Bayesian classifier: decision boundaries; nearest neighbour methods, and support vector machine (SVM); Unsupervised learning: k-means and hierarchical clustering, Feature extraction and feature selection; dimensionality reduction techniques: PCA, LDA and ICA, Introduction to Neural Networks: Modelling and applications to logic gates. Backpropagation learning algorithm: training and testing. Introduction to Convolution neural network (CNN): AlexNet, VGG architectures. Introduction to auto-encoder and generative adversarial networks (GAN).
7	**Contents for lab**	Experiments will be based on the theory covered as above.
8	**List of textbooks/references**	1. Christopher Bishop. Pattern Recognition and Machine Learning, 2nd Edition 2. EthemAlpaydin, Introduction to Machine Learning, 2nd Edition. 3. T. Hastie, R. Tibshirani, J. Friedman. The Elements of Statistical Learning, 2nd Edition, 2008.

1	**Code of the subject**	IT307
2	**Title of the subject**	Wireless Communication Technologies
3	**Any prerequisite**	Student should have basic knowledge of communication/data communication.
4	**L-T-P**	3-0-2
5	**Learning Objectives**	This course introduces the concepts of wireless/mobile communication using cellular technologies. It helps students to know about the various modulation techniques, propagation methods, and multi-access techniques used in mobile communication. It provides detailed ideas about path loss and shadow fading and how to solve such problems as also various types of diversity and their outage probability.
6	**Brief Contents**	Fundamentals of Communication: Fundamentals of Wireless Communication, Advantages, Limitations, and Applications, Multiple access technique: TDMA, CDMA, FDMA, CSMA, OFDMA, Frequency spectrum. Wireless Technology: The cellular concepts: Frequency Reuse, Channel assignment strategies, Handoff strategies Interference and System Capacity, Evolution of cellular networks, Path Loss and Shadowing Concepts, Diversity Techniques, Wireless local area networks, etc.
7	**Contents for lab**	Experiments will be based on the theory covered as above.
8	**List of textbooks/references**	1. Andrea Goldsmith, Wireless communication, Cambridge University Press, 2005. 2. Roy Blake, Wireless communication technologies, Leo Chartland, Delmar Cengage Learning, 1st edition, 2000. 3. Modern Wireless Communications by Simon O. Haykin and Michael Moher, Pearson, 1st edition (March 4, 2004) 4. Rappaport, Theodore S. Wireless communications: Principles and practice, 2nd Edition. Pearson Education India, 2010.

1	**Code of the subject**	IT404
2	**Title of the subject**	Software Engineering
3	**Any prerequisite**	N/A
4	**L-T-P**	3-0-2
5	**Learning Objectives**	To help students to develop skills that will enable them to construct software of high quality – software that is reliable, and that is reasonably easy to understand, modify and maintain
6	**Brief Contents**	Introduction, software life-cycle models, software requirements specification, formal requirements specification and verification - axiomatic and algebraic specifications, function-oriented software design, object-oriented design, UML, design patterns, user interface design, coding and unit testing, integration and systems testing, debugging techniques, software quality - SEI CMM and ISO-9001. Software reliability and fault-tolerance, software project planning, monitoring, and control, software maintenance, computer-

		aided software engineering (CASE), software reuse, component-based software development, extreme programming.
7	**Contents for lab**	Experiments will be based on the theory covered as above.
8	**List of text books/references**	1. Ian Sommerville, Software Engineering, Addison-Wesley 2. Rajib Mall, Fundamentals of Software Engineering, Prentice Hall India. 3. Pankaj Jalote, An integrated approach to Software Engineering, Springer/Narosa. 4. Roger S. Pressman, Software Engineering: A practitioner's approach, McGraw Hill.

1	**Code of the subject**	IT401
2	**Title of the subject**	Cloud Computing
3	**Any prerequisite**	Computer Networks, OS, Software engineering, Distributed Computing
4	**L-T-P**	3-0-0
5	**Learning Objectives**	To equip with the enabling technology for an on-demand access to a shared pool of configurable computing resources. To introduce various aspects of cloud computing paradigm and future research trends.
6	**Brief Contents**	Introduction to Cloud Computing, Introduction to Parallel and Distributed Computing, Cloud Computing Architecture, Service Management, Data Management in Cloud Computing, Virtualization & Resource Management, Cloud Security, Open Source and Commercial Clouds, Cloud Simulator, Research trend in Cloud Computing, Fog Computing.
8	**Text /references**	1. Cloud Computing: Principles and Paradigms, Editors: RajKumar Buyya, James Broberg, Andrzej M. Goscinski, Wiley 2. Enterprise Cloud Computing - Technology, Architecture, Applications, Gautam Shroff, Cambridge University Press 3. Cloud Computing Bible, Barrie Sosinsky, Wiley-India 4. Cloud Security: A Comprehensive Guide to Secure Cloud Computing, Ronald L. Krutz, Russell Dean Vines, Wiley

1	**Code of the subject**	IT402
2	**Title of the subject**	Digital Image Processing
3	**Prerequisite**	Mathematics
4	**L-T-P**	3-0-2
5	**Learning Objectives**	To introduce the basic concepts of Digital image processing with emphasis on applications in various field of recent research.
6	**Brief Contents**	Introduction and Fundamentals, Image Enhancement in Spatial Domain, Image Enhancement in Frequency Domain, Image Restoration, Segmentation, Representation and Description.

7	**Contents for lab**	Experiments are based on the theoretical contents and their applications
8	**Text /references**	1. Digital Image Processing 2nd Edition, Rafael C. Gonzalvez and Richard E. Woods. Published by: Pearson Education. 2.R.J. Schalkoff, Digital Image Processing and Computer Vision John Wiley and Sons, NY. 3. William K. Prat, Digital Image Processing, John Wiley and Sons, NY

1	**Code of the subject**	IT403
2	**Title of the subject**	Cryptography
3	**Any prerequisite**	Linear Algebra, Number Theory, and Combinatorics.
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject (in about 50 words)**	This course is largely about proving methods in the field of cryptography. This course is expected to build fundamental and deeper theoretical knowledge related to cryptography.
6	**Brief Contents**	Basics of Symmetric Key Cryptography, Asymmetric Key Cryptography, Hardness of Functions, Goldwasser-Micali Encryption, Goldreich-Levin Theorem, Attacks under Message Indistinguishability: Chosen Plaintext Attack (IND-CPA), Chosen Ciphertext Attacks (IND-CCA1 and IND-CCA2), Message Non-malleability Attacks like NMCPA and NM-CCA2, Inter-relations among the attack model, Pseudo-random Generators (PRG), Relation between One-way functions and PRG, Pseudo-random Functions (PRF), Left or Right Security (LOR), Formal Definition of Weak and Strong MACs, Using a PRF as a MAC, Variable length MAC, Public Key Signature Schemes, Assumptions for Public Key Signature Schemes, Shamir's Secret Sharing Scheme, Formally Analyzing Cryptographic Protocols, Zero Knowledge Proofs and Protocols.
7	**Contents for lab**	N/A
8	**List of text books/references**	1. Jonathan Katz and Yehuda Lindell, Introduction to Modern Cryptography, 2. Hans Delfs, Helmut Knebl, CRC Press, "Introduction to Cryptography, Principles and Applications", 3. Wenbo Mao, Springer Verlag., "Modern Cryptography, Theory and Practice", 4. Shaffi Goldwasser and Mihir Bellare, Pearson Education (Low Priced Edition), Lecture Notes on Cryptography

1	**Code of the subject**	IT399
2	**Title of the subject**	BTech Project/ Internship
3	**Any prerequisite**	No
4	**L-T-P**	0-0-12
5	**Learning Objectives**	To develop deeper knowledge, understanding, capabilities and attitudes in the context of the programme of study.

6	**Brief Contents**	The purpose of this course is to enable the student to develop deeper knowledge, understanding, capabilities and attitudes in the context of the programme of study. The student is expected to demonstrate the abilities of the major subject/field of study, including deeper insight into hardware/software application development work. Develop the capability to create, analyse and critically evaluate different technical/architectural solutions. Equip with the needed skills to clearly present and discuss the conclusions as well as the knowledge and arguments that form the basis for the learning outcome in written and spoken English. Importantly it is necessary to march on the ethical aspects of research and development work.
7	**Contents for lab**	There are no specific laboratory sessions for this. However, this being a completely practical oriented course, the student has to devote significant time to achieve the objectives.
8	**List of text books/references**	-----

1	**Code of the subject**	IT408
2	**Title of the subject**	Deep learning
3	**Any prerequisite**	Machine learning
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	This course will enable the learner to acquire the knowledge of applying Deep Learning techniques to solve various real life problems.
6	**Brief Contents**	Introduction to Deep Learning, Bayesian Learning, Decision Surfaces, Linear Classifiers, Linear Machines with Hinge Loss, Optimization Techniques, Gradient Descent, Batch Optimization, Neural Network, Multilayer Perceptron, Back Propagation, Unsupervised Learning with Deep Network, Autoencoders, Convolutional Neural Network, Transfer Learning, Revisiting Gradient Descent, Momentum Optimizer, RMSProp, Adam, early stopping, Dropout, Batch Normalization, Instance Normalization, Group Normalization, Residual Network, Skip Connection Network, Fully Connected CNN etc. Image Denoising, Semantic, Segmentation, Object Detection etc., LSTM Networks, Generative Modeling with DL, Variational Autoencoder, Generative Adversarial Network Revisiting Gradient Descent, Momentum Optimizer, RMSProp.
7	**Contents for lab**	N/A
8	**List of text books/references**	1. Ian Goodfelllow, YoshuaBenjio, Aaron Courville, Deep Learning-, The MIT Press. 2. Richard O. Duda, Peter E. Hart, David G. Stork, Pattern Classification, John Wiley & Sons Inc. 3. Wani, M. Arif, et al. Advances in deep learning. Springer, 2020.

1	**Code of the subject**	IT405
2	**Title of the subject**	Data Mining
3	**Any prerequisite**	N/A
4	**L-T-P**	3-0-2
5	**Learning Objectives**	Extract knowledge using data mining techniques. Explore recent trends in data mining such as web mining, spatial-temporal mining. Be acquainted with the tools and techniques used for Knowledge Discovery in Databases.
6	**Brief Contents**	Data Mining Concepts, Input, Instances, Types of Data, Data Mining Functionalities, Interestingness of Patterns, Classification of Data Mining Systems, Data Mining Task Primitive, Data Cleaning, Data Integration & Transformation, Data Reduction , Mining Frequent Patterns, Associations and Correlations, Mining Methods, Mining various Kinds of Association Rules, Decision Tree Induction, Bayesian Classification, Rule Based Classification, Classification by Back propagation, Support Vector Machines, Associative Classification, Lazy Learners, K-means Partitioning Methods, Multidimensional analysis & Descriptive mining of Complex data objects, Mining Spatial Databases, Mining Multimedia Databases, Mining Timeseries & Sequence data, Mining Text databases, Mining World -Wide Web Data Mining Applications and Trends in Data Mining, Massive Datasets/Text mining, Agent-Based Mining
7	**Contents for lab**	Experiments will be based on the theory covered as above.
8	**List of text books/references**	1. Jiawei Han and Micheline Kamber, ―Data Mining: Concepts and Techniques‖, Morgan Kaufmann Publishers, 2000 . 2. Ian H. Witten and Eibe Frank, ―Data Mining: Practical Machine Learning Tools and Techniques with Java implementations‖, Morgan Kaufmann Publishers, San Fransisco, CA (2000). 3. Dorian Pyle, ―Data Preparation for Data Mining‖, Morgan Kaufmann, (1999) 4. Korth, Silbertz, Sudarshan, ―Database Concepts‖, McGraw Hill 5. Elmasri, Navathe, ―Fundamentals of Database Systems‖, Addision Wesley

1	**Code of the subject**	IT406
2	**Title of the subject**	IoT and Applications
3	**Any prerequisite**	Basic programming knowledge
4	**L-T-P**	3-0-0
5	**Learning Objectives**	To expose the learner about the IoT and Cyber physical system paradigm, applications, underlying protocols.

6	**Brief Contents**	Sensing, Actuation, communication Protocols, Interoperability in IoT, IoT Middleware, IoT Software Platforms, Prototyping IoT Applications, IoT in the Cloud, Edge Analytics, Cyber Security and Privacy in Internet of Things, IoT Use Cases.
7	**Contents for lab**	N/A
8	**List of text books/references**	1. Pethuru Raj, Anupama C. Raman, "The Internet of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press. 2. Arshdeep Bahga, Vijay Madisetti, Internet of Things: A Hands-on Approach", Universities Press.

1	**Code of the subject**	IT407
2	**Title of the subject**	Mobile Computing
3	**Any prerequisite**	Computer Networks
4	**L-T-P**	3-0-0
7	**Learning Objectives**	Understand the basic concepts of mobile computing and different mobile platforms and applications.
8	**Brief Contents**	Introduction, Mobility Management, Data Management, Software Models, Context Sensing, Overview of Mobility models, Cloud-based services, Peer-to-peer applications, Delay-tolerance, Distributed transactions in mobile environments.
9	**Contents for lab**	N/A
10	**List of text books/references**	1. Pitoura, Evaggelia, and George Samaras. Data management for mobile computing. Vol. 10. Springer Science & Business Media, 2012. 2. Hansmann, LotharMerk, Martin Niclous, Stober, Principles of Mobile Computing 3. Tomasz Imielinski, Mobile Computing, Springer.

1	**Code of the subject**	IT409
2	**Title of the subject**	Blockchain Technologies
3	**Any prerequisite**	Distributed systems, networking, cryptography, and data structures
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	Be able to state core blockchain concepts, the benefits, and the limitations of blockchain technologies. Apply various blockchain concepts to analyze examples, proposals, case studies, and preliminary blockchain system design discussions.
6	**Brief Contents**	Intro to cryptography & cryptocurrencies, Bitcoin mechanics, Consensus protocols, Ethereum and decentralized applications, Decentralized finance and economics, Privacy on a public blockchain, Scaling the blockchain, Emerging Applications of Blockchain in industry

7	**Contents for lab**	N/A
8	**List of text books/references**	1. Narayanan, Arvind, et al. Bitcoin and cryptocurrency technologies: a comprehensive introduction. Princeton University Press, 2016. 2. Lewis, Antony. The basics of bitcoins and blockchains: an introduction to cryptocurrencies and the technology that powers them. Mango Media Inc., 2018. 3. Antonopoulos, Andreas M. Mastering Bitcoin: unlocking digital cryptocurrencies. " O'Reilly Media, Inc.", 2014.

1	**Code of the subject**	IT501
2	**Title of the subject**	Natural Language Processing
3	**Any prerequisite**	Linear algebra, Probability and Statistics, Python
4	**L-T-P**	3-0-2
7	**Learning Objectives**	To enable understand about the innovative real time applications using NLP components and implement rule-based systems.
8	**Brief Contents**	Human languages, models, ambiguity, processing paradigms; Phases in natural language processing, applications. Text representation in computers, encoding schemes. Introduction to corpus, elements in balanced corpus, TreeBank, PropBank, WordNet, VerbNet etc. Morphology, acquisition models, Finite State Transducer. Ngrams, smoothing, entropy, HMM, ME, SVM, CRF. Part of Speech tagging, Context Free Grammar, spoken language syntax. Parsing- Unification, probabilistic parsing, TreeBank. Semantics, lexical semantics, WordNet Word Sense Disambiguation- Selectional restriction, machine learning approaches, and dictionary-based approaches. Discourse- Reference resolution, constraints on co-reference, algorithm for pronoun resolution, text coherence, discourse structure. Applications of NLP.
9	**Contents for lab**	Experiments will be based on the theory covered as above.
10	**List of text books/references**	1. Daniel Jurafsky and James H Martin,Speech and Language Processing: An introduction to Natural Language Processing, Computational Linguistics and Speech Recognition‖, Prentice Hall, 2nd Edition, 2008. 2. Bird, Steven, Ewan Klein, and Edward Loper, Natural language processing with Python: analyzing text with the natural language toolkit. ", O'Reilly Media, Inc.", 2009. 3. Manning, Christopher, and Hinrich Schutze. Foundations of statistical natural language processing. MIT press, 1999.

1	**Code of the subject**	IT498
2	**Title of the subject**	Colloquium (Based on industrial training)/ MOOC
3	**Prerequisite**	
4	**L-T-P**	0-0-6
5	**Learning Objectives**	To instill the ability to identify skills and gain practical work experience To provide an opportunity to observe and contribute in the workplace To take ownership and responsibility of a project assignment, given by a designated manager/supervisor To provide networking opportunities with other members of the organization To offer performance feedback and mentorship throughout the internship
6	**Brief Contents**	An internship helps you train under experienced professionals and explore what your chosen career path would be like, and an internship with a company in your field can help you to develop the skills you require to thrive within a professional setting. At the end of the training period, the company may ask you to review your time with them and write a report based on your experience. In addition, hone the skills needed to develop internship report.
7	**Contents for lab**	There are no specific laboratory sessions for this. However, this being a completely practical oriented course, the student has to devote significant time to achieve the objectives.
8	**Text /references**	-----

1	**Code of the subject**	IT598
2	**Title of the subject**	M.Tech. Thesis Part-1
3	**Any prerequisite**	Art of Engineering Research and concerned research domain knowledge
4	**L-T-P**	0-0-24
5	**Learning Objectives**	To develop deeper knowledge, understanding, capabilities and attitudes in the context of the programme of study.
6	**Brief Contents**	The purpose of this course is to enable the student to develop deeper knowledge, understanding, capabilities and attitudes in the context of the programme of study. The student is expected to demonstrate the abilities of the major subject/field of study, including deeper insight into hardware/software application development work. Develop the capability to create, analyse and critically evaluate different technical/architectural solutions. Equip with the needed skills to clearly present and discuss theconclusions as well as the knowledge and arguments that form the basis for the learning outcome in written and

		spoken English. Importantly it is necessary to march on the ethical aspects of research and development work.
7	**Contents for lab**	There are no specific laboratory sessions for this. However, this being a completely practical oriented course, the student has to devote significant time to achieve the objectives.
8	**List of text books/references**	-----

1	**Code of the subject**	IT599
2	**Title of the subject**	M.Tech. Thesis Part-2
3	**Any prerequisite**	Art of Engineering Research, concerned research domain knowledge and M.Tech. Thesis Part-1
4	**L-T-P**	0-0-24
5	**Learning Objectives**	To continue research from M.Tech. Theis Part-1, develop further deeper knowledge, understanding, capabilities and attitudes in the context of the thesis.
6	**Brief Contents**	The purpose of this course is to enable the student to develop deeper knowledge, understanding, capabilities and attitudes in the context of the programme of study. The student is expected to demonstrate the abilities of the major subject/field of study, including deeper insight into hardware/software application development work. Develop the capability to create, analyse and critically evaluate different technical/architectural solutions. Equip with the needed skills to clearly present and discuss theconclusions as well as the knowledge and arguments that form the basis for the learning outcome in written and spoken English. Importantly it is necessary to march on the ethical aspects of research and development work.
7	**Contents for lab**	There are no specific laboratory sessions for this. However, this being a completely practical oriented course, the student has to devote significant time to achieve the objectives.
8	**List of text books/references**	https://grad.wisc.edu/wp-content/uploads/sites/329/2018/02/2018-Project-Management-for-Graduate-Students-Course-Workbook.pdf

1	**Code of the subject**	IT001
2	**Title of the subject**	Computer Vision
3	**Any prerequisite**	Machine learning
4	**L-T-P**	3-0-0

5	**Learning Objectives of the subject**	In this course, students will gain a broad understanding of the algorithms used for image segmentation, feature extraction and object detection. They will also understand the challenges involved in end-to-end machine vision system along with image acquisition, model deployment and actuation.
6	**Brief Contents**	Introduction to Image Processing system- Thresholding, Image Enhancement, Contrast Stretching, Image Histograms, Filters, Image Sharpening, Gradient based Edge Detection, finding corners, Using Scale and Orientation to Build neighborhood, SIFT, SURF, HOG feature detection, Computing local features, and Segmentation, Convolutional Neural Networks, Padding, Strided Convolution, Convolution over Volume, One layer Convolution, Pooling, object localization, object detection, Classic Networks, Transfer Learning, ImageNet Challenge, Feature extraction from videos and parallelization, Image Acquisition.
7	**Contents for lab**	N/A
8	**List of text books/references**	1. Forsyth and Ponce, Computer vision: A modern approach, Pearson, 2002. 2. Simon J.D. Prince, Computer vision: models, learning and inference, Cambridge University, 2012. 3. E. R. Davies, Computer Vision: Principles, Algorithms, Applications, Learning, Academic Press; 5th edition, 2017

1	**Code of the subject**	IT002
2	**Title of the subject**	Digital Signal Processing
3	**Any prerequisite**	N/A
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	The objective of this course to familiarize students with types of filters. Also, they will be able to design task-specific filters at the end of this course.
6	**Brief Contents**	Review of Signals and Systems: Discrete time complex exponentials and other basic signals-scaling of the independent axis and differences from its continuous-time counterpart-system properties (linearity, time-invariance, memory, causality, BIBO stability)-LTI systems, convolution, correlation, continuous-time Fourier series and Fourier transform. Sampling, Frequency Domain Analysis of LTI Systems, Discrete Fourier Transform (DFT), FIR and IIR Filter design.
7	**Contents for lab**	N/A
8	**List of text books/references**	1. Alan V. Oppenheim and Ronald W. Schafer, Discrete-Time Signal Processing by, 3rd edition, 2010, Prentice Hall, Upper Saddle River, NJ. 2. Sanjit Mitra,Digital Signal Processing, 4th edition, 2011, McGrawHill, New York, NY 3. John G. Proakis, Dimitris G. Manolakis, Digital Signal Processing, Principles, Algorithms, and Applications, Third Edition.

1	**Code of the subject**	IT003
2	**Title of the subject**	Pattern Recognition
3	**Any prerequisite**	Introductory courses on probability and linear algebra. Knowledge of basic programming languages.
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	After successful completion of this course, students should have a clear understanding of the basic steps of pattern recognition system, need of feature extraction and feature selection, and dimensionality reduction. Finally, students should have practical hands-on experience of implementing several pattern recognition techniques on real-time data.
6	**Brief Contents**	Introduction to pattern recognition (PR), data-sets, paradigms of PR. Representations of Patterns and Classes, Decision boundaries for binary-class/multiclass classification. problems. Supervised vs Unsupervised classification; Feature extraction and feature selection (dimensionality reduction). Bayesian Decision Theory, Linear Discriminant Function, Maximum Likelihood Estimation, and Bayesian Parameter Estimation and Support Vector Machines. Non-Parametric Techniques: Nearest Neighbor Methods and Parzen Window Method; Unsupervised Methods: PCA, LDA, LPP, K-means, and Mean-shift algorithm. State-space analysis: First-order Hidden Markov Models.
7	**Contents for lab**	N/A
8	**List of text books/references**	1. Christopher Bishop. Pattern Recognition and Machine Learning, Second Edition 2. R. O. Duda, P. E. Hart and D. G. Stork, Pattern Classification, Wiley, 2000. 3. Devi V.S.; Murty, M.N. (2011) Pattern Recognition: An Introduction, Universities Press, Hyderabad. 4. Lawrence R. Rabiner, Ronald W. Schafer, Digital Processing of Speech Signals

1	**Code of the subject**	IT004
2	**Title of the subject**	Information Retrieval and Extraction
3	**Any prerequisite**	N/A
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	To understand the theoretical basis behind the standard models of information retrieval, challenges. To understand the difficulty of representing and to be familiar with various IR algorithms and IR systems.

6	**Brief Contents**	Vector Space Model, Probabilistic Retrieval Strategies Language Models, Inference Networks, Extended Boolean Retrieval, Latent Semantic Indexing, Neural Networks Genetic Algorithms, Fuzzy Set retrieval, Fuzzy Information Retrieval System, Relevance feedback Clustering, Fuzzy Clustering, Passage based Retrieval N-grams, Cross-Language Information Retrieval Efficiency.
7	**Contents for lab**	N/A
8	**List of text books/references**	1. David A. Grossman and Ophir Frieder, Information Retrieval- Algorithms and Heuristic, second edition. Publisher: Springer. 2. R. Baeza-Yates and B. Ribeiro-Neto, "Modern Information Retrieval". 3. S. Büttcher, C. Clarke, and G. Cormack, Information Retrieval: Implementing and Evaluating Search Engines

1	**Code of the subject**	IT005
2	**Title of the subject**	Human Computer Interaction
3	**Any prerequisite**	N/A
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	The course is intended to introduce the student to the basic concepts of human-computer interaction. It will cover the basic theory and methods that helps student to design HCI.
6	**Brief Contents**	Foundations of Human–Computer Interaction: Human Capabilities, The Computer, The Interaction, Paradigms The Design Process: Interaction Design Basics, HCI in the Software Process, Design Rules, Universal Design Implementation Support: Implementation Tools, Evaluation and User Support Evaluation, User Support Users Models: Cognitive Models, Socio-organizational Issues and Stakeholder Requirements, Task Models and Dialogs Page: Analysing Tasks, Dialog Notations and Design, Groupware, Ubiquitous Computing, Virtual and Augmented Reality, Hypertext and Multimedia: Groupware and Computer-supported Collaborative Work, Ubiquitous Computing, Virtual Reality and Augmented Reality.
7	**Contents for lab**	N/A
8	**List of text books/references**	1. Alan Dix, Janet E. Finlay, Gregory D. Abowd, Russell Beale, Human-Computer Interaction. Harlow, England: Prentice Hall, 2004. 2. Yvonne Rogers, Helen Sharp, Jenny Preece, Interaction Design: Beyond Human Computer Interaction, 3rd Edition, Wiley, 2011 3. Preece, Jenny, et al. Human-computer interaction. Addison-Wesley Longman Ltd., 1994.

1	**Code of the subject**	IT006

2	**Title of the subject**	Digital Video Processing
3	**Any prerequisite**	N/A
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	At the end of this course, students will able to understand the knowledge within the area of intelligent video technology, with emphasis on motion tracking, enhancement and restoration, video segmentation and optimization.
6	**Brief Contents**	Video Sampling and Interpolation, Basic Linear Filtering with Applications to Image Enhancement, Computational Models of Early Human Vision, Motion Detection and Estimation, Video Enhancement and Restoration, Video Segmentation, Motion Segmentation, Tracking: Motion Tracking in Video, 2D and 3D Motion Tracking in Digital Video, Methods using Point Correspondences, Optical Flow and Direct Methods, Optimization: Pel-Recursive Methods, Bayesian Methods, Applications: Video Stabilization and Mosaicing, A Unified Framework for Video Indexing, Summarization, Browsing and Retrieval, Video Surveillance.
7	**Contents for lab (If applicable)**	N/A
8	**List of text books/references**	1. Alan Bovik, The Essential Guide to Video Processing 2. A Murat Tekalp, Digital Video Processing 3. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer-Verlag London Limited 2011.
1	**Code of the subject**	IT007
2	**Title of the subject**	Advanced Machine Learning
3	**Any prerequisite**	Machine Learning
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	The course objectives are to expose students to learn several advanced machine learning topics including variants of deep-learning models. Also, students will be emphasized to solve several real-time projects based on the concepts learned in the course.
6	**Brief Contents**	Review of Machine Learning, Neural Network, Learning algorithms – Backpropagation algorithm, Optimization algorithms, Deep Neural Networks and their variants, Convolutional Neural Networks, Generative Adversarial Network, Recurrent Neural Network, Transformer, etc. Projects related to different domains like health care, agriculture, automobile, etc.
7	**Contents for lab**	N/A
8	**List of text books/references**	1. Goodfellow, Ian, YoshuaBengio, and Aaron Courville. Deep learning. MIT press, 2016. 2. David Dietrich, Barry Heller and Beibei Yang, “Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data”, EMC Education Services, Reprint 2015, Wiley. 3. Tephen Marsland, “Machine Learning – An Algorithmic Perspective”, Taylor& Francis Group, Second Edition, 2015, Chapman & Hall / CRC Press.

1	**Code of the subject**	IT008
2	**Title of the subject**	Multimedia Processing
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	The course is intended to introduce the student to the concepts of multimedia systems, various coding, audio and video standards, resolution analysis and synchronization.
6	**Brief Contents**	Multimedia Systems and Processing, Lossless Image Compression Systems, Lossy Image Compression Systems: Theory of Quantization, Delta Modulation and DPC, Transform Coding & K-L Transforms, Discrete Cosine Transforms, Multi-Resolution Analysis: Theory of Wavelets, Multi-resolution Analysis: Theory of Sub-band Coding, Multi-resolution Analysis: Discrete Wavelet Transforms, Embedded Wavelet Coding, Image Compression Standards: JBIG and JPEG, JPEG-2000 Architecture and Features, JPEG-2000 Region of Interests Coding, JPEG-2000, Video Coding And Motion Estimation, Video Coding Standards: MPEG-1 standards, MPEG-2 Standard, MPEG-4 Standard, H.261 and H.263 Standards, H.264 standard, Audio Coding, Multimedia Synchronization, Video Indexing And Retrieval, state of the art video compression technique.
7	**Contents for lab**	N/A
8	**List of text books/references**	1 Alan Bovik, The Essential Guide to Video Processing. 2 Mark Nelson, *The Data Compression Book*, M&T Books, 1995. 3 Khalid Sayood, *Introduction to Data Compression*, Morgan Kaufmann, 1996. 4 J.F.K, Buford, Multimedia Systems, ACM Press, 1994

1	**Code of the subject**	IT009
2	**Title of the subject**	Digital Watermarking
3	**Any prerequisite**	Image Processing
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	This course enables students about different digital watermarking techniques, security aspects in it, deplorability and watermarking in real-world.
6	**Brief Contents**	Information Hiding, Steganography, and Watermarking, Importance of Digital Watermarking, Steganography, Applications and Properties, Models of Watermarking: Communication-Based Models of Watermarking, Geometric Models of Watermarking, Modelling Watermark Detection by Correlation; Basic Message Coding, Robust Watermarking, Watermark Security: Security Requirements, Watermark Security and Cryptography, Some Significant Known Attacks; Content Authentication.

7	**Contents for lab**	N/A
8	**List of text books/references**	1. Ingemar J. Cox, Matthew L. Miller, Jeffrey A. Bloom, Jessica Fridrich, Ton Kalker, Morgan Kauffman, Digital Watermarking and Steganography, 2007 2. Ingemar J. Cox, Matthew L. Miller, Jeffrey A. Bloom, Morgan Kauffman, Digital Watermarking principles, 2007. 3. Introduction to Watermarking Techniques and Applications, AP Lambert Academic, 2020

1	**Code of the subject**	IT010
2	**Title of the subject**	Applied Image Processing
3	**Any prerequisite**	Image Processing
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	To introduce the basic concepts of Digital image processing with emphasis on applications in various field of recent research.
6	**Brief Contents**	Review of Image processing techniques, filtering in spatial and frequency domain, Image segmentations, object representations, Industrial applications of image processing, Biomedical applications of image processing, Image processing in healthcare and agriculture etc.
7	**Contents for lab**	N/A
8	**List of text books/references**	1. G. J. Awcock, Ray Thomas, Applied Image Processing, McGraw-Hill, 1996 2. Rafael C. Gonzalvez and Richard E. Woods, Digital Image Processing 2nd Edition, Published by: Pearson Education. 3. R.J. Schalkoff, Digital Image Processing and Computer Vision John Wiley and Sons, NY. 4. William K. Prat, Digital Image Processing, John Wiley and Sons, NY.

1	**Code of the subject**	IT011
2	**Title of the subject**	Cognitive Radio
3	**Any prerequisite**	Digital Communication
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	The students will be enabled to understand and acquire knowledge in cognitive networks. To emphasis on knowledge-building to understand architectures for various networks. To provide a complete understanding of concepts, and to identify the pros and cons of designing a cognitive network and SDR.

6	**Brief Contents**	Introduction of various generations of wireless communication, Spectrum scarcity, cognitive radio (CR) architecture, functions of cognitive radio, Fundamental challenges, and issues in designing cognitive radio. Spectrum access models, dynamic spectrum access (DSA), underlay, overlay, and hybrid cognitive radio, Potential applications of cognitive radio. Interference temperature/channel estimation, Detection of spectrum holes, Practical spectrum sensing approaches, Collaborative sensing, External Sensing. Framework of Trust in CRN; Trusted Association and Routing; Trust with Learning; Security in CRN. Introduction to SDR. Evolution of SDR Baseband Requirements. SDR Architectures -Ideal SDR Architectures, Realistic SDR Architecture. SDR and Cognitive Radio Relationship.
7	**Contents for lab**	N/A
8	**List of text books/references**	1. Hoseyin Arslan (Ed.), "Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems," Ser. Signals and Communication Technology, xviii, I. edition, Springer, Aug. 2007 2. Joseph Mitola, III, "Cognitive Radio Architecture: The Engineering Foundations of Radio XML," John Wiley and Sons Ltd., 2006. 3. Kwang-Cheng Chen and Ramjee Prasad, Cognitive Radio Networks, John Wiley & sons, 2009. 4. Ahmed Khattab, Dmitri Perkins, Magdy Bayoumi, Cognitive Radio Networks: From Theory to Practice, Springer, 2013.

1	**Code of the subject**	IT012
2	**Title of the subject**	Next Generation Networks
3	**Any prerequisite**	It is desirable to have the knowledge of Data networking and Telecommunications principles.
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	After successful completion of this course, students will able to learn emerging network technologies, their features, challenges, advantages, and disadvantages. To learn how broadband data and multimedia services are carried out to users over a common Multi-Service Infrastructure.
6	**Brief Contents**	Introduction To Next Generation Networks (NGN): Communication and Networking in coming Era, Technologies influencing change, NGN Services, Network Infrastructure convergence, services convergence etc., Overview of Wireless network and Technologies GSM, 1G, 2G, 3G and 4G, Bluetooth, Radio frequency, Overview Of TCP/IP, LANs, WANs. Optical Networks, Wire-line and Wireless Networks, General packet radio service (GPRS): GPRS and packet data network, network architecture, operation, and data services in GPRS. Applications of GPRS, Billing, and charging in GPRS,

		Ad-hoc network: Architecture and Protocols, Wireless LAN, IEEE802.11a, 802.11b standards, Wireless LAN architecture, Mobile ad hoc networks, and sensor network.
7	**Contents for lab**	N/A
8	**List of text books/references**	1. Neill Wilkinson, "Next Generation Networks Services, Technologies, and Strategies", Wiley, 2002. 2. Robet Wood, "Next Generation Network Services", Pearson, 2005. 3. YB. Lin and I Chlamtac, "Wireless and Mobile Network Architectures", Wiley, 2001 4. A.S. Tanenbaum, "Computer Networks", Pearson Education, 2003.

1	**Code of the subject**	IT013
2	**Title of the subject**	Queuing Theory
3	**Any prerequisite**	Basic knowledge of Engineering Mathematics and
4	**L-T-P**	3-0-0
5	**Learning Objectives of the**	To teach the applications of queuing theory related to
6	**Brief Contents**	Basics of Probability and Statistics, Random processes- Introduction, classification, Stationary process – Wide Sense Stationary, Strict Sense Stationary, Markov Process, Markov Chain, Problems based on Markov Process. Transition probabilities, Limiting distributions, Poisson Process - Properties, Poisson Process - Problems Queuing system – introduction, Markovian Models, Birth and Death Process, Little's Formula, M/M/1, Infinite Capacity, M/M/1, Finite Capacity, M/M/c, Infinite Capacity, M//M/c, Finite Capacity and finite population, M/M/ queue. Non Markovian queues- M/G/1 queue, GI/M/1 queue, GI/M/m queue, GI/G/1 queue, M/G/m queue, GI/G/m queue, Pollaczek- Khinchine formula. Priority queues-Queues with preemption, queues with time dependent priorities. Series queues, Open Networks, Closed Networks, batch service, batch arrival.
7	**Contents for lab**	N/A
8	**List of text books/references**	1. K. S. Trivedi, Probability and Statistics with Reliability, Queuing and Computer Science Applications, John Wiley and Sons, 2nd edition, 2002. 2. A.O. Allen, Probability, Statistics and Queuing Theory with Computer Applications, Elsevier, 2nd edition, 2005. 3. Srivastava, H. M., & Kashyap, B. R. K. (1982). Special functions in queuing theory and related stochastic processes. ACADEMIC PRESS. 4. Dimitri P. Bertsekas and Robert G. Gallager, "Data Networks," (2nd edition) Prentice Hall, 1992

		5. Leonard Kleinrock, Wiley-Interscience, Queueing Systems, Volume I; 1st edition (1 January 1975).

1	**Code of the subject**	IT014
2	**Title of the subject**	Network design and optimization
3	**Any prerequisite**	Basics of wireless communications
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	Students will acquire knowledge of the planning and optimization of wireless networks and their specifications. The course will discuss the working principles of different types of networks and their performance optimization.
6	**Brief Contents**	Review of all Network Technologies, Study of Various Quality of service aspects in wired and wireless Networks based on applicative scenarios and their optimization.
7	**Contents for lab**	N/A
8	**List of text books/references**	1. D. Medhi and K. Ramasamy, Network Routing: Algorithms, Protocols, and Architectures - 2nd Edition, Morgan Kaufmann Publishers (an imprint of Elsevier), publication date: September 11, 2017. 2. D. Medhi and K. Ramasamy, Network Routing: Algorithms, Protocols, and Architectures, Morgan Kaufmann Publishers (an imprint of Elsevier), publication date: March 29, 2007. 3. M. Pióro and D. Medhi, Routing, Flow, and Capacity Design in Communication and Computer Networks, Morgan Kaufmann Publishers (an imprint of Elsevier), publication date: July 1, 2004.

1	**Code of the subject**	IT015
2	**Title of the subject**	Advanced Wireless Communications
3	**Any prerequisite**	Introduction to Probability and Statistics, Introduction to
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	The course provides advanced knowledge in a number of transmission techniques and technologies in wireless communications. It covers the fundamentals of MIMO communications. Other advanced topics are also viewed to update students with emerging techniques and developments in 5G.
6	**Brief Contents**	Basics of single-user Multiple-Input-Multiple-Output (MIMO) communications – Channel models, outage capacity, ergodic capacity – Diversity techniques: time, frequency, space and diversity combiners – Precoding for spatial multiplexing, optimum, linear and nonlinear

		receivers – Space-time coding and MIMO decoding. Emerging techniques and applications in 5G–Cooperative communications, Device-to-device (D2D) communications, Green and energy-efficient communications, –Internet of Things (IoT) networks and Low Power Wide Area Network (LPWAN) technologies.
7	**Contents for lab**	N/A
8	**List of text books/references**	1. D. Tse and P. Viswanath, "Fundamentals of wireless communication", 2005. 2. R. W. Heath Jr. and A. Lozano, "Foundations of MIMO Communication", 2018. 3. Liu, KJ Ray, et al. Cooperative communications and networking. Cambridge university press, 2009. 4. E. Bjornsson, J. Hoydis, L. Sanguinetti, "Massive MIMO Networks: Spectral, Energy, and Hardware Efficiency", 2017.

1	**Code of the subject**	IT016
2	**Title of the subject**	Multimedia Networks
3	**Any prerequisite**	N/A
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	The course is aimed at developing students' ability to understand and apply the fundamental ideas that govern the design of the architecture of modern multimedia communication networks to real problems.
6	**Brief Contents**	Multimedia networks principles, Audio video streaming, Jitter problems, Multicast, principles, and protocols, Multimedia Protocols – SIP, RTSP, etc., Traffic engineering and Quality of services, Queuing architectures, Content in Distributed network, CDN architecture.
7	**Contents for lab**	N/A
8	**List of text books/references**	1. Multimedia Communications: Protocols and Applications, Prentice Hall, 1998 2. Multimedia Communications: Protocols and Applications, F. Kuo, W. Effelsberg, andJ.Garcia-Luna-Aceves, Prentice Hall PTR, 2000 3. Multimedia over IP and Wireless Networks: Compression, Networking, and Systems, by M. Van der Schaar, P. Chou, Academic Press, 2007. 4. Multimedia Communications Applications, Networks, Protocols and Standards Fred Halsall, Addison Wesley, 2001

1	**Code of the subject**	IT017

2	**Title of the subject**	Industrial IoT Communication
3	**Any prerequisite**	Basic understanding of industrial plants, physics of the real world, Computer communications, Machine Learning.
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	The candidates will learn about the emerging digitization issues associated with factory floor, various approaches to data collection and processing using machine learning techniques.
6	**Brief Contents**	Industry 4.0: The PDP loop concept, IoT reference architecture; Connecting Brownfield environments: Overview of existing and the state-of-the-art manufacturing plants, Smart factories, digitization and cloud centric IoT systems, Advancements in industrial IoT, applications and solutions – case studies, issues and challenges in brownfield connectivity. Connectivity layers: Issues with placing together different data logging sensors. Hardware and software approaches to data collection and condition monitoring of industrial processes: Gateways, connectivity agents; Enterprise systems: Edge analytics, Integration of multiple data systems, Data value mapping, low-code application development; Open IoT.
7	**Contents for lab**	N/A
8	**List of text books/references**	1. Alasdair Gilchrist (Apress), “Industry 4.0: The Industrial Internet of Things” 2. Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat (Springer), “Industrial Internet of Things: Cyber manufacturing Systems”. 3. White papers and research articles.

1	**Code of the subject**	IT018
2	**Title of the subject**	Detection and Estimation Theory
3	**Any prerequisite**	Student must have basic knowledge about linear algebra,
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject (in about 50 words)**	The students will learn to mathematically formulate appropriate detection and estimation problems, solve these problems to get good/best detectors and estimators and analyze their performance. This is a math-oriented course and will use concepts from probability and linear algebra.
6	**Brief Contents**	Review of Gaussian variables and processes, Statistical Decision Theory: Bayesian, minimax, and Neyman-Pearson decision rules, likelihood ratio, composite hypothesis testing, Detection of Deterministic Signals: Matched filter detector and its performance. Detection of Random Signals: Estimator- correlator, linear model, general Gaussian detection. Nonparametric Detection: Detection in the absence of complete statistical description of observations. Estimation of Signal Parameters: Minimum variance unbiased estimation, Fisher information matrix, Cramer-Rao bound,

		sufficient statistics. Signal Estimation in Discrete-Time: Linear Bayesianestimation, Weiner filtering, dynamical signal model, discreteKalman filtering.
7	**Contents for lab**	N/A
8	**List of text books/references**	1. H. L. Van Trees, Detection, Estimation and Modulation Theory, John Wiley and sons 2004. 2. Signal detection and estimation by Mourad Barkat, ArtechHouse 1991. 3. An Introduction to Signal Detection and Estimation by Poor,H. Vincent, Springer 1998.

1	**Code of the subject**	IT019
2	**Title of the subject**	Distributed System
3	**Any prerequisite**	Fundamentals of distributed systems, Basic knowledge of software systems. Basic programming skills in a mainstream programming language.
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	The candidates will learn about the principles of distributed systems and contrast with other forms of computation, identify applications of distributed systems in particular the use of cloud and serverless applications, big data and graph processing applications, interactive and online gaming, etc.; analyze and design core architectures, components, and techniques in distributed systems.
6	**Brief Contents**	Introduction to Distributed Systems: Parallel versus distributed systems, challenges, CAP theorem; Functional requirements: Naming, replication, consistency, consensus; Non-functional requirements: Measuring NFRs, scalability and elasticity etc.; Resource management and scheduling: scheduling issues for small and large systems, centralized and decentralized schedulers, portfolio scheduling; System architecture and programming models: Communication, big data, machine learning, layering; Distributed ecosystems: massive processing, the super-distribution principle, cloud, edge, big data, Distributed ecosystems in online gaming etc.
7	**Contents for lab**	N/A
8	**List of text books/references**	1. Von Bochmann, Gregor, “Concepts for distributed systems design”, Springer Science & Business Media, 2012. 2. Van Steen, Maarten, and Andrew S. Tanenbaum, “Distributed systems”. 3. Sukumar Ghosh, “Distributed systems”, CRC Press 4. Ajay D. Kshemkalyani and Mukesh Singhal, “Distributed computing: Principles, algorithms and systems”, Cambridge press.

1	**Code of the subject**	IT020
2	**Title of the subject**	Information Theory and Coding
3	**Any prerequisite**	Linear algebra
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	This course gives brief knowledge about the basic algebraic relationships of entropy, relative entropy, and mutual information. In this course students learn how to compress the data using source coding and how to make data transmission reliable using channel coding. It introduces the basic principles of encoding, decoding, error detecting and error correcting techniques.
6	**Brief Contents**	Information Theory: Introduction, Discrete memory less source, Binary source.Entropy, Relative Entropy, and Mutual Information, Channel capacity, Data Compression Examples of Codes, Kraft Inequality, Optimal Codes, Bounds on the Optimal Code Length, Kraft Inequality for Uniquely Decodable Codes, Huffman Codes, Shannon–Fano Coding, etc.Error detecting and Error correcting code, Block Codes, Cyclic Codes, Convolution Codes
7	**Contents for lab**	N/A
8	**List of text books/references**	1. Joy A. Thomas and Thomas M. Cover, Elements of Information Theory, John Wiley and Sons. 2. John G. Proakis, McGraw Hill, Digital Communication Singapore, 4th Edition, 2001. 3. Bernard Sklar, Digital Communications: Fundamentals and Applications, 2nd Ed., Pearson Prentice Hall, 2001.

1	**Code of the subject**	IT021
2	**Title of the subject**	Convex Optimization
3	**Any prerequisite**	Basic knowledge of Engineering Mathematics and Statistics
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	To learn the concepts and applications of optimization for solving real world problems.
6	**Brief Contents**	**Linear Programming:** Convex sets, Mathematical Model, Assumptions of linear programming, Graphical method Simplex method, Big M Method, Two-Phase Method, Exceptional cases in LPP. **Duality in Linear Programming:** Dual simplex method, revised simplex method, sensitivity or Post-optimal analysis, Transportation problem, Assignment Problem. **Integer Programming Problem:** Cutting plane method, Gomory's cut method, Branch and bound technique, Travelling salesman problem, Cargo loading problem.

		Non-linear Programming: Quadratic forms and classical methods, Convex functions and Kuhn-Tucker theory, Beale's method, Separable programming. **Dynamic Programming and Game Theory:** Bellmen's principle, Recursive relations, Solution of LPP by dynamic programming, Game theory, games with mixed strategy, Stochastic linear programming.
7	**Contents for lab**	N/A
8	**List of text books/references**	1. Taha, H.A., 1992. Operations Research (5th edn), Prentice Hall Publication. 2. Hillier, F.S. and Lieberman, G.J., 1967. Introduction to operations research. San Francisco: Holden-Day. 3. Ravindran, A, Phillips, DT, Solberg, JJ. 1987. Operations Research: Principles and Practice, John Wiley 4. Boyd, Stephen, Stephen P. Boyd, and Lieven Vandenberghe. Convex optimization. Cambridge university press, 2004.

1	**Code of the subject**	IT022
2	**Title of the subject**	Digital Watermarking and Steganalysis
3	**Any prerequisite**	N/A
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	The objective of the course makes students familiar about Digital watermarking and steganography.
6	**Brief Content**	Information Hiding, Steganography, and Watermarking, Importance of Digital Watermarking, Applications and Properties. Models of Watermarking: Communication-Based Models of Watermarking, Geometric Models of Watermarking, Modelling Watermark Detection by Correlation; Basic Message Coding: Mapping Messages into Message Vectors, Error Correction Coding, Detecting Multi-symbol Watermarks; Watermarking with Side Information: Informed Embedding, Watermarking Using Side Information, Dirty-Paper Codes; Robust Watermarking: Approaches, Robustness to Volumetric Distortions, Robustness to Temporal and Geometric Distortions; Watermark Security: Security Requirements, Watermark Security and Cryptography, Some Significant Known Attacks; Content Authentication: Exact Authentication, Selective Authentication, Localization, Restoration; Notation and Terminology, Information-Theoretic Foundations of Steganography, Practical Steganographic Methods, Minimizing the Embedding Impact; Steganalysis: Steganalysis Scenarios, Some Significant Steganalysis Algorithms.
7	**Contents for lab (If applicable)**	N/A

8	**List of text books/references**	1. Ingemar J. Cox, Matthew L. Miller, Jeffrey A. Bloom, Jessica Fridrich, Ton Kalker, Morgan Kauffman, Digital Watermarking and Steganography. 2. Ingemar J. Cox, Matthew L. Miller, Jeffrey A. Bloom, Morgan Kauffman, Digital Watermarking principles 3. Frank Y. Shih, Digital Watermarking and Steganography: Fundamentals and Techniques, Second Edition CRC Press.

1	**Code of the subject**	IT023
2	**Title of the subject**	Cryptography and Network Security
3	**Any prerequisite**	Linear Algebra
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	To enhance the ability to analyse, identify and define the computing requirements for data security.
6	**Brief Contents**	Classical Encryption Techniques, Finite Field and Number Theory, Polynomial Arithmetic, Prime Numbers, Fermat's And Euler's Theorem, Testing For Primality, Key Management, Elliptic Curve Arithmetic, Elliptic Curve Cryptography. Cryptographic Protocols, Digital Signatures. Authentication applications, IP security, Encapsulating Security Payload (ESP)-Internet Key Exchange (Phases of IKE, ISAKMP/IKE Encoding). Web Security: Web Security Considerations, Secure Socket Layer and Transport layer Security. System Security: Intrusion Detection, Virus and related threats, Firewalls, Trusted Systems.
7	**Contents for lab**	N/A
8	**List of text books/references**	1. William Stallings, Cryptography and Network security, 4e, Prentice Hall of India, New Jersey, 2008. 2. Christof Paar, Jan Pelzl, Understanding Cryptography, Springer-Verlang, Berlin, 2010 3. Behrouz A Forouzan, Cryptography and Network security, Tata Mc-Graw Hill, New York, 2007.

1	**Code of the subject**	IT024
2	**Title of the subject**	Distributed System Security
3	**Any prerequisite**	Basics of Distributed System

4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	This is a course that will cover advanced security concepts beyond traditional offerings. Emphasis will be made on all aspects of cyber security including vulnerabilities, threats, attacks and defences in distributed systems.
6	**Brief Contents**	Security Requirements of Distributed Systems; Security Violations, Security Goals, Security Services, Security Protocols, and Security Mechanisms; Attack on Security Protocols and Security Mechanisms; Secret Sharing Techniques and One-Way Functions; Discrete Logs, Block Encryption/Decryption Functions, Hash Functions, and MAC Functions; Algorithmic Implementation and Security Requirements of One-Way Functions; OS Security Violations and Techniques to Prevent Them; Access Control Models; Authenticated Diffie-Hellman Key Establishment Protocols; Group Key Establishment Protocols; Block Ciphers and Stream Ciphers; Block Cipher Modes of Encryption; Nonce, Timestamps and Authentication Protocols; Digital Page 1/6Signatures and Source Non-Repudiation Protocols; PKI and X.509 Authentication Service; Security Protocol Verification: Strand Space Theory; Kerberos; E-mail Security; Security Issues in Layered Communication Models: IP Security, Secure Socket Layer and Transport Layer Security; Secure Electronic Transactions; Intrusion Detection; Malicious Software Detection; Firewalls.
7	**Contents for lab**	N/A
8	**List of text books/references**	1. Anirban Chakrabarti, Distributed Systems Security: Issues, Processes and Solutions 1st Edition by Abhijit Belapurkar (Author), Wiley, 2009. 2. Ajay D. Kshemkalyani and MukeshSinghal, “Distributed Computing: Principles, Algorithms, and Systems”, Cambridge University Press, 2011. 3. Andrew S. Tanenbaum and Maarten van Steen, “Distributed Systems: Principles and Paradigms”, Second Edition, Pearson Prentice-Hall, 2007.

1	**Code of the subject**	IT025
2	**Title of the subject**	Cyber Security and Laws
3	**Any prerequisite**	N/A
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	To realize the activities carried using forensic technologies in detection of cybercrime. To introduce a novel methodology of performing cyber forensics or system forensics. To relate the laws enforced by the judiciary to handle cybercrimes and cyber

6	**Brief Contents**	Mobile Forensics, Computer Ethics and Application Programs, Cyber Forensic, Data Recovery, Introduction to Deleted File Recovery, Formatted Partition Recovery, Data Recovery Tools, Data Recovery Procedures and Ethics, file modification and file access, Recover Internet Usage Data, Recover Swap Files/ Temporary Files/Cache Files, Introduction to Encase Forensic Edition, Forensic Tool Kit (FTK), Introduction to IT laws & Cyber Crimes, Introduction to Cyber Forensic Investigation, Investigation Tools, eDiscovery, Digital Evidence Collection, Evidence Preservation, E-Mail Investigation, E-Mail Tracking, IP Tracking, E-Mail Recovery, Encryption and Decryption methods, Search and Seizure of Computers, Recovering deleted evidences, Password Cracking, Introduction to Cyber Security, Implementing Hardware Based Security, Software Based Firewalls, Security Standards, Assessing Threat Levels, Forming an Incident Response Team, Reporting Cyber crime, Operating System Attacks, Application Attacks, Reverse Engineering & Cracking Techniques and Financial Frauds, Security Audit and Standards.
7	**Contents for lab**	N/A
8	**List of text books/references**	1.Raghu Santanam, Sethumadhavan, Mohit Virendra, Cyber Security, Cyber Crime and Cyber Forensics: Applications and Perspectives, IGI Global 2. Chris Davis, IT Auditing Using controls to protect Information Assets, TMH 3. Hamid Jahankhani, Cyber Criminology, Springer.

1	**Code of the subject**	IT026
2	**Title of the subject**	Advanced Cryptography
3	**Any prerequisite**	Basics of Cryptography
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	This course investigates advanced topics in cryptography. It begins with an overview of necessary background in algebra and number theory, private- and public-key cryptosystems, and basic signature schemes. The course will cover number theory and basic theory of Galois fields used in cryptography, discrete logarithm-based cryptosystems including those based on elliptic curves; interactive protocols including the role of zero-knowledge proofs in authentication.
6	**Brief Contents**	Review of the prerequisite Cryptography: Private-key cryptosystems; Advanced Encryption Standard (AES), Overview of modular arithmetic, discrete logarithms, and primality/factoring, Public-key cryptosystems; ElGamal cryptosystem, Basic signature schemes. Algebra and number theory: Rings of polynomials, Existence and finding primitive roots, Blum integers, Primes; Agrawal,

		Kayal, Saxena P-time algorithm for recognizing primes, Elliptic curves. Discrete logarithm-based cryptosystems and signatures: Elliptic Curve Cryptosystem (ECC), Digital Signature Standard (DSS), Selection of other signature schemes, Overview of discrete logarithm algorithms, Ethical aspects of public-key cryptosystems and signatures, Hashing, emerging SHA-3 standard. Interactive protocols: Touch of complexity theory, Interactive proof systems, 0-knowledge proof systems, 0-knowledge authentication, Electronic cash; Chaum and Brands schemes. Private information retrieval: AES news, SHA-3 news, Private/public/group/share key generation and management, Digital watermarking, digital fingerprinting, Steganography. Selected topics in quantum computing, Quantum computers, Shor's algorithm, future demise of RSA, Quantum cryptography, Quantum key distribution and reconciliation
7	**Contents for lab**	N/A
8	**List of text books/references**	1. Douglas R. Stinson, Cryptography: Theory and Practice, CRC Press, fourth edition 2019. 2. Alfred J. Menezes, Paul C. van Oorschot and Scott A. Vanstone, CRC Handbook of Applied Cryptography, CRC Press. 3. Lawrence C. Washington, Elliptic Curves. Number Theory and Cryptography, Chapman and Hall, CRC Press 2003.

1	**Code of the subject**	IT027
2	**Title of the subject**	Information Security and Secure Coding
3	**Any prerequisite**	Basics of Cyber Security
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	To learn how secure coding is important when it comes to lowering risk and vulnerabilities. Identify the insecure coding practices that lead to common software programming errors. Learn about XSS, Direct Object Reference, Data Exposure, Buffer Overflows, Resource Management, Active Defences, and Threat Modelling.
6	**Brief Contents**	Introduction to Information security and Secure coding, Injections (SQL, command, JSON), defenses, Broken authentication and Session management. Cross-site Scripting (reflected XSS HTML, reflected XSS JS), Insecure direct object reference, Security misconfiguration. Sensitive data exposure, Missing function level access control, Cross-site request forgery. Using components with known vulnerabilities, Invalidated redirects and forwards. Buffer overflows, Insecure interaction between components. Risky resource management, Porous defences, Active defences, Threat modeling.

7	**Contents for lab**	N/A
8	**List of text books/references**	1. "Fundamentals of Cyber Security", Mayank Bhushan, Rajkumar Singh Rathore, Aatif Jamshed, *BPB Publications*. 2. "Building Secure Software: How to Avoid Security Problems the Right Way", Viega, John, Gary McGraw, *Maddison-Wesley Professional*. 3. "Foundations of Information Security: A Straightforward Introduction", Jason Andress, No Starch Press, US.

1	**Code of the subject**	IT028
2	**Title of the subject**	Malware Analysis
3	**Any prerequisite**	Networks and Operating Systems, Computer security.
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	This course will introduce students to modern malware analysis techniques through readings and hands-on interactive analysis of real-world samples. After successful completion of this course students will be equipped with the skills to analyze advanced contemporary malware using both static and dynamic analysis.
6	**Brief Contents**	Introduction to malware, Basic Static and Dynamic Analysis, Overview of Windows file format, PEView.exe, Patching Binaries , Disassembly (objdump, IDA Pro), Introduction to IDA, Introduction to Reverse Engineering, Extended Reverse Engineering using GDB and IDA, Advanced Dynamic Analysis - debugging tools and concepts, Malware Behavior - malicious activities and techniques, Knowledge of relevant system internals, and experience in using various malware analysis tools Analyzing Windows programs–WinAPI, Handles, Networking , COM, Data Encoding, Malware Counter measures, Covert Launching and Execution, Anti Analysis - Anti Disassembly, VM, Debugging -, Packers – packing and upacking, Intro to Kernel – Kernel basics, Windows Kernel API, Windows Drivers, Kernel Debugging, Rootkit Techniques- Hooking, Patching, Kernel Object Manipulation , Rootkit Anti-forensics, Covert analysis.
7	**Contents for lab**	N/A
8	**List of text books/references**	1. Michael Sikorski and Andrew Honig, Practical Malware Analysis, No Starch Press,2012 2. Reverend Bill Blunden, The Rootkit Arsenal: Escape and Evasion in the Dark Corners of the System, Second Edition 3. Jamie Butler and Greg Hoglund, Rootkits: Subverting the Windows Kernel. 4. Dang, Gazet, Bachaalany, Practical Reverse Engineering, Wiley,2014

1	**Code of the subject**	IT029
2	**Title of the subject**	Formal methods for Security Verifications
3	**Any prerequisite**	Operating Systems Concepts, Information System Security
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	To make use of mathematical background to understand and use formal methods like set theory, propositional logic and operational semantics
6	**Brief Contents**	Introduction to Formal Methods, Mathematical Background, Formal Specifications, Case Study Formal Specifications and Models, Model Checking and Formal Verification, Advanced models: Real-time models , Case Study Formal Verification , Static and Dynamic Analysis of programs, temporal logic: CTL and LTL, Buchi automata, Explicit model checking, BDDs and model-checking with BDDs, symbolic model checking, SAT and model-checking with SAT, Security verification, hybrid automata, hybrid system verification, applications of model checking to hardware, software, and protocols verification.
7	**Contents for lab**	N/A
8	**List of text books/references**	1. Edward Griffor, Handbook of System Safety and Security. 2. Ulrich Kühne, Rolf Drechsler, Formal Modeling and Verification of Cyber-Physical Systems. 3. Michael Huth and Mark Ryan, Logic in Computer Science: Modelling and Reasoning about Systems, Cambridge Univ. Press, 2nd edition

1	**Code of the subject**	IT030
2	**Title of the subject**	IoT and its security
3	**Any prerequisite**	
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	The objective of this course is to acquaint participants with some of the fundamental concepts and state-of-the-art research in the areas of IoT and its Security.
6	**Brief Contents**	Introduction to IoT, potential security challenges in IoT paradigm, Architecture, Protocols, Performance Modeling& Analysis, Industrial IoT (IIoT) and the Industrial Internet Consortium (IIC), IoT Security solutions, Emerging IoT Standards, Open Problems & Research challenges.
7	**Contents for lab**	N/A

8	**List of text books/references**	1. Chintan Patel Nishant Doshi, Internet of Things Security: Challenges Advances and Analytics, T&F/CRC Press. 2. Cheruvu, Apress, Demystifying Internet of Things Security. 3. Al-Turjman, Security InIot-Enabled Spaces, CRC Press. 4. Russell, Brian and Drew Van Duren, Practical Internet of Things Security, Packt Publishing, 2016.

1	**Code of the subject**	IT033
2	**Title of the subject**	Parallel and Concurrent Programming
3	**Any prerequisite**	Advanced Computer Architecture, C/C++ Programming
4	**L-T-P**	3-0-0
5	**Learning Objectives of the**	The Course exposes the learner to know the various parallel
6	**Brief Contents**	Introduction to Parallel and Distributed Systems: Parallel Programming Paradigms, Parallel Architecture, Principals of Parallel Programming, Models of Parallel Computation, Complexity, PRAM, Memory Consistency & Performance Issues, Memory Consistency & Performance Issues, Shared Memory & Message Passing. OpenMP: Introduction to OpenMP, Work Sharing, Scheduling, Synchronization, Tasks, Environment Variables, and Run-Time Library Routines, Other Clauses and Directives. MPI: Basics of MPI, Cost Model, One-sided/two-side communication, Hybrid programming (MPI + OpenMP). Introduction to CUDA: GPU architecture, high-performance computing on GPUs, parallel algorithms, CUDA libraries, and applications of GPU computing. Introduction to the design of parallel algorithms and hands-on.
7	**Contents for lab**	N/A
8	**List of text books/references**	1. Chandra et al, ―Parallel Programming in OpenMP, Morgan Kaufmann. 2. Chapman, Jost, and van der Pas, ―Using OpenMP: Portable Shared Memory Parallel Programming, MIT Press. 3. Tanenbaum, Andrew S. Distributed operating systems. Pearson Education India, 1995. 4. Programming Massively Parallel Processors (3rd Edtion)

1	**Code of the subject**	IT034
2	**Title of the subject**	Scientific Computing and Numerical Methods
3	**Any prerequisite**	Engineering Mathematics
4	**L-T-P**	3-0-0

5	**Learning Objectives of the subject**	To demonstrate an understanding of common numerical methods and how they are used to obtain approximate solutions to otherwise intractable mathematical problems. To apply numerical methods to obtain approximate solutions to mathematical problems.
6	**Brief Contents**	Introduction, types of errors, Bisection Method, False Position Method, Newton-Raphson Method, Gauss Jordan Methods, etc and their Convergence. Finite Difference Operators and Their Relationships, Difference Tables, Differentiation Continuous Functions, Differentiation of Tabulated Functions, Higher Order Derivatives Newton-Cotes Integral Formula, Trapezoidal Rule, Simpson‘s Rules, Boole‘s Rule and Weddle‘s Rule, Romberg Integration, Taylor Series Method, Picard‘s Method, Runga-Kutta methods, etc.
7	**Contents for lab**	N/A
8	**List of text books/references**	1. Balagurusamy, E., Numerical Methods, Tata McGraw Hill Education Pvt. Ltd., 1999. 2. Sastry, S. S., Introductory Methods of Numerical Analysis, PHI Learning Pvt Ltd., 2012. 3. Jain, M. K., Iyengar, S.R.K and Jain, R.K, Numerical Methods for Scientific and Engineering computation, Wiley Eastern Ltd., 1985.

1	**Code of the subject**	IT035
2	**Title of the subject**	Optimization Techniques
3	**Any prerequisite**	Exposure to relevant concepts at the undergraduate level and instructor consent
4	**L-T-P**	3-1-0
5	**Learning Objectives**	The aim of this course is to have some basic understanding of provably convergent computational schemes for constrained optimization problems.
6	**Brief Contents**	Solving Linear constraint optimization problem, Non-linear programming: First and second order conditions. Iterative methods and associated issues. Line search methods: Stationarity of limit points of steepest decent, successive step-size reduction algorithms, etc. Hessian-based algorithms: Newton, Conjugate directions and Quasi-Newton methods. Constrained optimization problems: Lagrange variables, Karush-Kuhn-Tucker conditions, Regular points, Sensitivity analysis. Quadratic programming, Convex problems. Mixed integer models; Interior point methods; Iterative schemes for constrained problems; Sequential quadratic programming methods; Barrier methods; Trust-region methods, etc.
7	**Contents for lab**	Experiments will be based on the theory covered as above.

8	**List of textbooks/references**	1. Boyd, Stephen, Stephen P. Boyd, and Lieven Vandenberghe. Convex optimization. Cambridge university press, 2004. 2. D. Bertsekas Nonlinear programming, 2nd Edition, Athena Scientific, 1999, Nashua. 3. V. Chvatal Linear programming, W. H. Freeman, 1983, New York. 4. E. K. P. Chong and S. Zak, An introduction to optimization, 2nd Edition, 2004, John Wiley and Sons (Asia) Pvt. Ltd., Singapore 5. R. Fletcher, Practical methods of optimization, 2nd Edition, Wiley, 2000, New York 6. D. Luenberger, Linear and nonlinear programming, 2nd Edition, 1984, Kluwer Academic Publisher, New York 7. O. L. Mangasarian, Nonlinear programming, SIAM, 1987, Philadelphia

1	**Code of the subject**	IT036
2	**Title of the subject**	Big Data Analytics
3	**Any prerequisite**	N/A
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	The course focuses on big data computer system, storage, processing, analysis, visualization, and applications. State-of-the-art computational frameworks for big data.
6	**Brief Contents**	Overview of Big Data, State-of-the-art computing paradigms/platforms, Big data programming tools (e.g., Hadoop, MongoDB, Spark, etc.), Big data extraction and integration, Big data storage, Scalable big data indexing, Large-scale graph processing techniques, Big data stream techniques and algorithms, Large-scale probabilistic data analysis, Big data privacy, Big data visualizations, problems in real applications.
7	**Contents for lab**	N/A
8	**List of text books/references**	1. Kuan-Ching Li, Hai Jiang, Laurence T. Yang, and Alfredo Cuzzocrea. Big Data: Algorithms, Analytics, and Applications. Chapman & Hall/CRC Big Data Series, 2015. 2. Thomas Erl, Wajid Khattak, and Dr. Paul Buhler. Big Data Fundamentals: Concepts, Drivers & Techniques. The Prentice Hall Service Technology Series, 2016. 3. Wajid Khattak, Paul Buhler, Thomas Erl, Big Data Fundamentals: Concepts, Drivers & Techniques, John Wiley & Sons, Inc

1	**Code of the subject**	IT037
2	**Title of the subject**	IC Technology
3	**Any prerequisite**	Nil

4	**L-T-P**	3-0-0
5	**Learning Objectives**	Students will be able to learn: • Fundamental principles of fabrication of VLSI devices and circuits. • To demonstrate a clear understanding of CMOS fabrication flow and technology scaling • To demonstrate a clear understanding of various MOS fabrication processes, semiconductor measurements, packaging, testing and advanced semiconductor technologies.
6	**Brief Contents**	Historical perspective, processing overview, crystal growth, wafer fabrication and basic properties of Silicon Wafers, Clean Rooms, Wafer Cleaning, Epitaxy, Thermal Oxidation of Silicon, Lithography, Wet and Dry Etching, Thin film deposition technique (ALD), Diffusion, Ion Implantation, Metallization, Process Integration: Passive components, Bipolar Technology, MOSFET Technology, CMOS Technology, MESFET Technology, MEMS Technology, IC Manufacturing: Electrical Testing, Packaging, Yield, Future trends and Challenges: Challenges for integration, system on chip, Novel Devices.
7	**Contents for lab**	NA
8	**List of text books/references**	• Fundamentals of Semiconductor Fabrication by G. S. May and S. M. Sze, Wiley. • Silicon VLSI Technology, Fundamentals, Practice and Modeling by J. D. Plummer, M. D. Deal and P. B. Griffin, Pearson education. • VLSI Technology by S. M. Sze, TMH. • Semiconductor Devices: Physics and Technology by S. M. Sze, Wiley. • Semiconductor Integrated Circuit Processing Technology by W. R. Runyan and K. E. Bean, Addison Wesley Publishing Company. • The Science and Engineering of Microelectronic Fabrication by S. A. Campbell, Oxford University Press. • Fundamentals of Microfabrication by M. J. Madou, CRC Press.

1	**Code of the subject**	IT038
2	**Title of the subject**	Program Analysis Verification and Testing
3	**Any prerequisite**	Discrete Mathematics, Data Structures, Theory of Computation
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	To provide overview of the theoretical fundamentals of the subject also to provide information of some of the modern verification and testing tools.

6	**Brief Contents**	Dataflow Analysis, Interprocedural Analysis: functional, call-string and graph reachability based approaches; Abstract Interpretation, Weakest Precondition, Floyd-Hoare Logic, Separation Logic; Software Model Checking: symbolic execution, state-space reduction, state-less model checking, counter-example guided abstraction refinement, model checking of concurrent programs; Program Testing: program testing basics, automatic test-case generation, directed testing
7	**Contents for lab**	N/A
8	**List of text books/references**	1. Edsger Wybe Dijkstra. A Discipline of Programming. Prentice Hall PTR, Upper Saddle River, NJ, USA. 2. Michael Huth and Mark Ryan. Logic in Computer Science: Modelling and Reasoning about Systems. Cambridge University Press, New York, NY, USA 3. Alfred V. Aho, Monica S. Lam, Ravi Sethi, and Jeffrey D. Ullman. Compilers: Principles, Techniques, and Tools (2nd Edition). Addison-Wesley Longman Publishing Co., Inc., Boston, MA, USA, 2006.

1	**Code of the subject**	IT040
2	**Title of the subject**	Competitive programming
3	**Any prerequisite**	Data structures and algorithms
4	**L-T-P**	3-0-0
5	**Learning Objectives of the subject**	The focus of the course is the development and implementation of advanced algorithms, as well as the skills required for programming competitions.
6	**Brief Contents**	Introduction; Problem formats; Online judging systems; Parsing Input; Formatting Output, Review of Fundamental Data Structures), Divide and Conquer, Greedy, and Dynamic Programming Approaches; Graph Algorithms-search, shortest path, minimum spanning tree, network flow, bipartite graph matching, String Processing- edit distance, subsequences, suffixes) Numerical algorithms and Combinatorics, Chinese Remainder Theorem and modular math, Large number computations, generating and counting permutations and combinations, Applications of Geometric Algorithms 2D line segment and polygon queries –intersection, area; calculations on a sphere; 3D volume calculations; ray-surface intersection; convex hull; spatial subdivisions, Basic heuristic search, Advanced search and Simulation problems
7	**Contents for lab**	N/A
8	**List of text books/references**	1. Halim, Steven, Felix Halim, and Suhendry Effendy. Competitive programming 4: The new lower bound of programming contests in the 2020s, 2018.

		2. Laaksonen, Antti. Guide to competitive programming. Cham: Springer, 2020. 3. Skiena, Steven S., and Miguel A. Revilla. "Programming challenges: The programming contest training manual." Acm SIGACT News 34.3 (2003): 68-74.

1	**Code of the subject**	IT-019
2	**Title of the subject**	Generative Artificial Intelligence
3	**Any prerequisite**	Fundamentals of Machine Learning and Deep Learning
4	**L-T-P**	3-0-0
5	**Learning objectives of the subject (in about 50 words)**	This course will introduce students with a foundational understanding of Generative AI, including models like GANs, VAEs, and diffusion models.
6	**Brief contents**	Introduction to AI, Machine Learning, and Deep Learning, Overview of Generative AI and its real-world applications, Bayesian Networks, Hidden Markov Models (HMMs), Text and image representation in generative AI, Introduction to Variational Autoencoders and their architecture, Introduction to Generative Adversarial Networks (GANs), Variants of GANs, Energy-Based Models and Normalizing Flows, Representation learning for generative tasks. Introduction to Transformers: Self-attention mechanism and architecture, pre-trained language models, Large Language Models (LLMs): Text generation and conversational AI., Introduction to Diffusion Models and Denoising Diffusion Probabilistic Models (DDPM), Interpretability and explainability in generative models., Generative AI applications in art, healthcare, and synthetic data generation, Deployment strategies, Ethical considerations, Evaluation metrics.
7	**Contents for lab**	

1	**Code of the subject**	IT-020
2	**Title of the subject**	**Large Language Models**
3	**Any prerequisite**	Fundamentals of Machine Learning, Deep Learning, and NLP
4	**L-T-P**	3-0-0
5	**Learning objectives of the subject (in about 50 words)**	This course will introduce students with the foundational and advanced concepts of Large Language Models (LLMs), including deep learning, transformers, and NLP techniques.
6	**Brief contents**	Neural network fundamentals (Backpropagation, Optimization), Feed Forward Neural Network, Recurrent Neural Network: RNN. LSTM, GRU, Attention Mechanism Traditional Text Representations: One-Hot Encoding, Bag of Words (BoW) and TF-IDF. Word Embeddings Era: Word2Vec Embedding: Continuous Bag of Words (CBOW) & Skip-gram Model; GloVe ; FastText. Contextual Word Embeddings (Modern NLP): ELMo , ULMFiT.. Transformer architecture (Multi-Head Self Attention, Positional Encoding), Training objectives (Masked Language Modeling, Causal LM). Long-Document Transformers: Reformer, Longformer, BigBird. Multimodal Transformers:CLIP , Flamingo. Vision Transformer (ViT): Swin Transformer, DETR BERT (Bidirectional Encoder Representations from Transformers), RoBERTa , DistilBERT, ALBERT. GPT (Generative Pre-trained Transformer): GPT-1, GPT-2 GPT-3, GPT-4. Large-scale dataset preparation and preprocessing, Transfer learning & fine-tuning strategies, Metrics: Macro F1, Micro F1, and Weighted Average F1, Perplexity, BLEU, ROUGE, GLUE benchmarks, Explainability techniques (Grad-CAM, SHAP, LIME), Bias, fairness, and ethical AI challenges, Adversarial attacks and robustness of LLMs, Case studies.
7	**Contents for lab**	

CODE WITH MSxxx

1	**Programme**	MBA/IMG
2	**Semester**	I/VII
3	**Type of course**	Core
4	**Code of the subject**	MS601
5	**Title of the subject**	Principles and Practices of Management
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Element of Management is concerned with the way in which organizations manage their resources. The aim is to explore the concepts of management, managers, and organizations in today's dynamic environment. This course outline illustrates the varied backgrounds, skills, and characteristics required for successful managers. It continues with an examination of the functions of management, managerial roles and diverse nature of modern business organizations, and rewards and challenges offered by a career in management.
9	**Brief Contents**	Explain what is meant by the term management, Classify the three levels of managers and identify the primary responsibility of each group, Describe the difference between managers and operative employees, Explain the skills and roles manager, Describe the value of studying management, Identify the relevance of popular humanities and social science courses to management practices, Define planning. Explain the potential benefits of planning, Distinguish between strategic and tactical plans, Define management by objectives and identify its common elements, Outline the steps in the strategic management process, Explain SWOT analysis, Describe the steps in the decision-making process, Identify the assumptions of the rational decision-making model, Define certainty, risk, and uncertainty as they relate to decision making, Identify the two types of decision problems and the two types of decisions that are used to solve them, Describe the advantages and disadvantages of group decisions, Identify and define the six elements of organization structure, Contrast mechanistic and organic organizations, Summarize the effect of strategy, size, technology, and environment on organization structures, Contrast the divisional and functional structures, Define leader and explain the difference between managers and leaders, Describe the skills that visionary leader exhibit, Explain the styles and theories of leadership, Define Motivation at work, Techniques of motivation, Theories of motivation, Explain what is meant by the term learning organization, Define control, Describe three approaches to control, Explain why control is important, Describe the control process, Distinguish among the three types of control, Describe

		the qualities of an effective control system, Explain how controls can become dysfunctional
10	**Contents for lab**	No

1	**Programme**	MBA
2	**Semester**	I
3	**Type of course**	Core
4	**Code of the subject**	MS602
5	**Title of the subject**	Business Statistics
6	**Any prerequisite**	Basic knowledge of mathematics and statistics
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	To understand the role of statistics in the field of business management. To understand the process associated with statistical decisions, defining and formulating problems, analysing the data, and using the results in decision making.
9	**Brief Contents**	Introduction to Statistics, Charts and Graphs, Measures of central tendency, Measures of dispersion, Probability, Discrete probability distribution, Continuous probability distribution Sampling and sampling distributions, Statistical inference: Estimation for single populations, Statistical inference: Hypothesis testing for single population, Statistical inference: Hypothesis testing for two populations, Analysis of variance and Experimental designs, Hypothesis testing for categorical data (chi-square test), Simple linear regression analysis , Multiple regression analysis, Time series and Index numbers, Statistical quality control, Non-parametric statistics, Statistical decision theory
10	**Contents for lab**	Application of appropriate statistical software

1	**Programme**	MBA
2	**Semester**	I
3	**Type of course**	Core
4	**Code of the subject**	MS603
5	**Title of the subject**	Business Economics
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Managerial Economics is the use of economic theory and mathematical and statistical techniques in order to examine how a firm can make optimal managerial decisions given the constraints it faces. The main objective of this course is to equip students with the necessary theory and techniques and the ability to apply them in order to inform and enhance managerial decision making. Topics covered include: goals of the firm, optimization techniques, demand theory and estimation, forecasting and measurement, theory of production and

		estimation, cost theory and estimation, pricing and output determination under different market structures, game theory, and pricing in practice.
9	**Brief Contents**	Introduction to Economics; Nature and Scope of Management Economics, Significance in decision-making and fundamental concepts, Consumer behaviour and typical characteristics of Indian consumer, Consumer decision making process, Indian market: characteristics, Objectives of a firm, Demand Analysis, Law of Demand, Exceptions to the law of Demand, Determinants of Demand. Elasticity of Demand- Price, Income, Cross and Advertising Elasticity, Uses of Elasticity of Demand for managerial decision making, Measurement of Elasticity of Demand, Demand forecasting meaning, significance and methods, Supply Analysis, Law of Supply, Supply Elasticity, Analysis and its uses for managerial decision making, Production concepts & analysis, Production function, single variable-law of variable proportion, two variable-Law of returns to scale, Cost concept and analysis, short-run and long-run cost curves and its managerial use, Market Equilibrium and Average Revenue Concept, Market Structure: Perfect Competition, features, determination of price under perfect competition, Monopoly: Feature, pricing under monopoly, Price discrimination, Monopolistic: Features, pricing under monopolistic competition, product differentiation, Oligopoly: Features, kinked demand curve, cartels, price leadership, Pricing strategies Price determination, Full cost pricing, Product line pricing, Price skimming, Penetration pricing, National Income; Concepts and various methods of its measurement, Inflation, types and causes, Business cycle, Profit concept and major theories of profits; Dynamic Surplus theory, Risk & Uncertainty bearing theory and Innovation theory
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	I/VII
3	**Type of course**	Core
4	**Code of the subject**	MS604
5	**Title of the subject**	Business and Legal Environment
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	This course will give orientation to the students about different forms of organizations, functions in organizations, business environment and strategies, along with an exposure to basic elements of company laws, economics laws, industrial and labour laws, foreign exchange management act in business perspective.
9	**Brief Contents**	Concepts of Vision and Mission statements, Types of Environments, Business Environment with reference to Global integration, Forms of business organisation: Scales of business;

		Emerging trends in business, Company Laws: The Companies Act 2013, Limited Liability Partnership Act, 2008, The insolvency and bankruptcy code 2016, Economic Laws: FDI Policy-Foreign Direct Investment in India and abroad, External Commercial Borrowing (ECB), Formalities-Establishment of Branch Office of a foreign entity in India, Foreign Trade Policy-Opportunities of commerce/finance professional in foreign trade-Procedure of import and export-Export promotion schemes and initiatives, Competition Commission of India-Compliance of competition law, Industrial and Labour laws: Overview of Industrial Policy of Govt. of India, Regulatory Mechanism under IDRA, MSME Development Act, Advantages of MSMEs and their role and significance in economic development, Central and State Schemes for MSME Promotion-Udyog Aadhar, Foreign Exchange Management Act: Features and Application-Opportunities for Indian Business Challenges, Foreign Contribution (Regulation) Act 2010
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	I/VII
3	**Type of course**	Core
4	**Code of the subject**	MS605
5	**Title of the subject**	Financial Reporting and Control
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	After the completion of this course, students will be able to understand the role and relevance of financial accounting in management and its implications for a business entity, and utility of cost and management accounting information as a vital input for management and decision-making process.
9	**Brief Contents**	Introduction, nature and scope of financial and management accounting, GAAP and accounting environment, Principles, concepts and conventions of accounting, Accounting process, Construction of profit and loss statement, Balance sheet and cash flow statement, Concept of financial statements analysis, Horizontal and vertical Analysis, Trend analysis, Ratio analysis, Cash flow statement analysis, Cost accounting and information, Types of cost, Preparation of cost sheet, Activity-based costing, Concepts of budget and budgetary control, Static and flexible budgets, Preparation of sales budget, Production budget, Material budget, Cash budget, Master budget, Concept of standard costing and variance analysis, Setting of standards, Analysis of material variances, Labour variances and overhead variances, Marginal costing and absorption costing, Marginal costing, and its applications, Cost-volume-profit analysis, Concept of contribution

		and break-even analysis and its uses, Margin of safety and angle of incidence.
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	I/VII
3	**Type of course**	Core
4	**Code of the subject**	MS606
5	**Title of the subject**	Organizational Behavior
6	**Any prerequisite**	General Understanding of Management Functioning
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	To provide a comprehensive analysis of individual and group behaviour in the organizations. To provide an understanding of how organizations can be managed more effectively and at the same time enhancing the quality of employees work life.
9	**Brief Contents**	What is organizational behaviour?, OB as an interdisciplinary subject ,The Individual: Diversity in the organizations, attitudes and job satisfaction, emotions and moods, personality and values, perception and individual decision making, motivation concepts, motivation: from concepts to applications The Group: Foundations of group behaviour, understanding work teams, communication, leadership, power and politics, conflict and negotiations, foundations of organization structure, The Organization system Organizational culture, human resource policies and practices, organizational change and stress management
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	I/VII
3	**Type of course**	Core
4	**Code of the subject**	MS607
5	**Title of the subject**	IoT and Big Data Management
6	**Any prerequisite**	Fundamentals of Computer/ Computer organization and any programming language
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Upon course completion, students will be able to: Understand deploying smart applications on different IoT platforms. Develop Interface of various sensors, I/O devices and I/O peripherals with N/W Protocols. Understand the impact of big data for business decisions and strategy. Gain hands-on experience on large-scale analytics tools to solve some open big data problems. Understand the concept and challenge of big data and why existing technology is inadequate to analyze the big data

9	**Brief Contents**	Design principles and needed capabilities, AI applications in IoT Applications, Sensing, Actuation, Basics of networking, M2M and IoT technology fundamentals- devices and gateways, Data management, Business processes in IoT, Everything as a Service (XaaS), Role of Cloud in IoT, Security aspects in IoT, Components selection criterion for implementing IoT application, Hardware components computing (Node MCU, Raspberry Pi), Communication, Sensing, Actuation, I/O interfaces, Software components- programming API's (using Python/Node.js/Arduino), Sensors interfacing: Interfacing of temperature, Humidity, Light, Accelerometer, Ultrasonic, IR/PIR, Camera etc, Communication and I/O components, Interfacing: bluetooth, WiFi, GSM, Displays and touch sensor etc., Types of Digital Data, Introduction to Big Data, Big Data Analytics, Relational Databases & SQL, Data Cleansing and Preparation, History of Hadoop, Apache Hadoop, Analysing Data with Unix tools, analyzing data with Hadoop, Hadoop Streaming, IBM Big Data Strategy, Infosphere Big Insights and Big Sheets, HDFS (Hadoop Distributed File System): The Design of HDFS, HDFS concepts, Command Line Interface, Hadoop file system interfaces, Data flow, Data ingest with Flume and Scoop and Hadoop archives, NoSQL, Types of NoSQL database, Advantages, New SQL, Comparison of SQL, NoSQL and NewSQL., Supervised learning with regression and classification techniques, Bias-Variance trade-off, Model validation approaches, Logistic regression, Linear discriminant analysis, Quadratic discriminant analysis, Ensemble methods: random forest neural networks, Deep learning unsupervised learning and challenges for big data analytics, Clustering, associative rule mining, Challenges for big data analytics prescriptive analytics, Creating data for analytics through designed experiments, Creating data for analytics through active learning, Creating data for analytics through reinforcement learning.
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	III/IX
3	**Type of course**	Core
4	**Code of the subject**	MS608
5	**Title of the subject**	International Business
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0

8	**Learning Objectives of the subject**	The goal of this course is to introduce participants to the field of international business. This course will make participants familiar with three basic areas: underlying theories of international business, environmental factors affecting international activities, and the management of business functional operations in an international context. In addition, participants will learn how to analyse international situations and evaluate contemporary issues in international business.
9	**Brief Contents**	Background for International Business: Globalization and International Business, Comparative Environmental Frameworks: The Cultural environments facing business, The Political and Legal environments facing business, The Economic environments facing business, Globalization and Society, Theories and Institutions: Trade and Investment: International trade and Factor mobility theory, Governmental Influence on trade, Cross-National cooperation and agreements World Financial Environment Global Foreign: Exchange markets, The Determination of Exchange rates, Global capital markets, Global Strategy, Structure, and Implementation: The Strategy of international business, Country evaluation and selection, Export and Import, Direct investment and Collaborative strategies, The Organization of international business, Managing International Operations: Marketing globally, Global operations and supply-chain management, International accounting and finance issues, International human resource management
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	II/VIII
3	**Type of course**	Core
4	**Code of the subject**	MS609
5	**Title of the subject**	Human Resource Management
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Human Resource Management (HRM) is concerned with the way in which organizations manage their people. The aim is to chart some of the broad terrain of a rapidly developing field of study in order to prepare the students for the more finely grained treatment of specific HRM topics. This course outline examines the recent rise of HRM, the effects of the changing context of work on HRM, what it involves, and the strategic nature of HRM practice, its impact on organizational performance and the changing role of HRM function.

9	**Brief Contents**	Define HRM, Describe the Nature, Feature and Scope of HRM, Describe the major activities of HRM, Explain the skills and roles of Human Resource manager, Why HRM is important to all managers, List the challenges and opportunities of HR manager, Define Job Analysis, Explain types of Job analysis, Understand Job Analysis Process, Describe the basic methods of collecting the Job analysis information, Define HR planning, Describe the need and objectives of HR planning, Understand the HR planning model, Explain the factors affecting HR planning, Define Recruitment, Explain essential steps for Recruitment Planning, Understand Recruitment model, Describe sources of Recruitment, Explain the Pros and Cons of recruitment, Define selection , Steps / process of selection, Define Employee training, Explain need and objectives of training, Differentiate between training and development, Describe the principles, areas and benefits of training, Understand the Training Methods, Describe Training system model, Understand levels of training evaluation, Define Career and its related terms, Understand stages of growth and career, Describe Career-planning process and its responsibility, Understand the benefits of Career development system, Know the career program for special target groups, Explain the Model or Designing organizational career development, Define Performance appraisal, Explain why it is important to effectively appraise performance, Understand features, purposes and objectives of performance appraisal. Describe the methods of performance appraisal. List the criticism of performance appraisal.
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	II/VIII
3	**Type of course**	Core
4	**Code of the subject**	MS610
5	**Title of the subject**	Operations Management
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Upon successful completion of the course, student should be able to: Understand the role of operations in both manufacturing and service organizations. Describe the importance of facilities location decision in the end-to-end supply chain. Develop understanding of a range of inventory models available their

		contextual suitability. Employ different quality prescriptive and the tools of statistical process control.
9	**Brief Contents**	Operations and strategy: nature, evolution and scope of production and operations management, Emerging trends in operations management, Operations strategy: linkage with competitive strategy and formulation of operations strategy, Facility Planning: facilities location: globalization of operations, Factors affecting location decisions, Location planning methods, Linkage with supply chain network design decisions, Process Management: Design of production process and facility layout, Process design and analysis, Design of products and services: process of product and service design, Tools, Critical chain, Just-in-time, Lean operations and Toyota production system, Inventory Management: deterministic models, Probabilistic models: multi-period and single period (news vendor) models, Selective inventory models, Aggregate production planning (APP), Master production schedule (MPS), Materials requirements planning (MRP), Quality management, Statistical process control (SPC), Process capability and Six Sigma.
10	**Contents for lab**	Simulation exercises on Arena

1	**Programme**	MBA/IMG
2	**Semester**	II/VIII
3	**Type of course**	Core
4	**Code of the subject**	MS611
5	**Title of the subject**	Marketing Management
6	**Any prerequisite**	Basic understanding of microeconomics
7	**L-T-P**	3-0-1
8	**Learning Objectives of the subject**	To understand the fundamental marketing concepts and the processes that influences the market orientation of a firm. To understand the role of marketing within the organization. To recognize the importance of marketing in the competitive world. To analyze critically the marketing process and its relationship with the environment within which it operates. To broadly look at the role of Marketing as a key element within an organization's strategy.
9	**Brief Contents**	Introduction to Marketing- Definition of marketing, Marketing environment, Business models and value chain, Segmentation and targeting- Concept of segmentation, Bases of segmentation (B2C & B2B), Targeting, Application in real life scenario, Positioning and differentiation- Differentiation parameters, POP& POD, Competition, Consumer Behavior- Consumer

		decision making process, factors influencing consumer behavior, B2B Marketing- Organizational decision making process, buying roles, Marketing strategy (product, service and pricing decisions)- Product strategy, branding, service, pricing strategy, Marketing strategy (place decisions)- Channels of distribution, Distribution strategy, Marketing strategy (promotion decisions)- Integrated marketing communication, Advance topics in marketing- Predictive, contextual, augmented and agile marketing.
10	**Contents for lab**	Simulation on marketing environment Case study exercises Class projects and exercises Field projects and company visits

1	**Programme**	MBA/IMG
2	**Semester**	II/VIII
3	**Type of course**	Core
4	**Code of the subject**	MS612
5	**Title of the subject**	Financial Engineering and Management
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	The course aims at providing an understanding of financial engineering and management concepts. This will enable to understand how corporations make investment & financing decisions with dynamic risk exposures. It will help develop the financial engineering fundamentals for proper risk mitigation.
9	**Brief Contents**	Changing Financial arena and associated risks, Financial engineering as a response to increased risks, Types of Risks and Risk management, Financial markets, Financial institutions, Financial services, Financial instruments,. Financial Management: Nature, Scope, and Objectives of financial management, Time value of money, Risk and return, Capital Structure and Cost of Capital: Capital structure theories and leverage, Optimum capital structure, Measurement of specific costs, Computation of overall cost of capital. Financing Decision: Long-term financing, Short-term financing, Term financing, Venture capital. Capital Budgeting: Principles, Techniques, Measurement, evaluation, and involved risk analysis, Working Capital Management: Planning of working capital, Working capital financing, Cash management, Receivable management and Inventory management. Dividend Policy Decision: Dividend and valuation, Determinants of dividend policy, The Futures Markets, Static and dynamic hedging, Devising a Hedging Strategy Using Futures, Stock

		Index Futures, Value at Risk (VaR), Short Term and Long Term Interest Rate Futures, Foreign Currency Futures and Commodity Futures, Options Markets; Properties of Stock Option Prices; Option Pricing Models – Binomial Model, Black-Scholes; Model, Single Period Options –Calls and Puts, Option Strategies, Multi-Period Options – Caps, Floors, Collars, Captions, Swaptions and Compound options, Cross-currency Futures and Options, Structure of a Swap, Interest Rate Swaps, Currency of Swaps, Commodity Swaps, Other Swaps, Credit Risk and Credit Derivatives, Credit default swaps, Role of a Swap Dealer. Basics of FRAs, Emerging Innovations and recent trends
10	**Contents for lab**	No

1	**Programme**	MBA
2	**Semester**	II
3	**Type of course**	Core
4	**Code of the subject**	MS613
5	**Title of the subject**	Business Research Methods
6	**Any prerequisite**	Basic knowledge of business statistics
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	To design and execute a basic survey research project. To understand the research tools and techniques for executing a business project and decision making.
9	**Brief Contents**	Introduction to business research: Business research methods: An introduction, business research process design, Research design formulation: Measurement and scaling, questionnaire design, sampling and sampling distributions, Sources and collection of data: Secondary data sources, data collection: survey and observations, experimentation, fieldwork and data preparation, Data analysis and presentation: Statistical inference: hypothesis testing for single population, hypothesis testing for two populations, analysis of variance and experimental designs, hypothesis testing for categorical data (chi-square test), non-parametric statistics, Correlation and simple linear regression analysis, Multivariate analyses (Multiple regression analysis, discriminant analysis, conjoint analysis, factor analysis, cluster analysis, multidimensional scaling, correspondence analysis), Result presentation: Presentation of results, report writing
10	**Contents for lab**	Data analysis and presentation: Statistical inference: hypothesis testing for single population, hypothesis testing for two populations, analysis of variance and experimental designs, hypothesis testing for categorical data (chi-square test), non-parametric statistics, Correlation and simple linear regression analysis, Multivariate analyses (Multiple

		regression analysis, discriminant analysis, conjoint analysis, factor analysis, cluster analysis, multidimensional scaling, correspondence analysis)

1	**Programme**	MBA
2	**Semester**	II
3	**Type of course**	Core
4	**Code of the subject**	MS614
5	**Title of the subject**	Decision Modelling and Optimization
6	**Any prerequisite**	Basic Knowledge of Mathematics, Probability distributions and Statistics.
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	The objectives of the course is to acquaint the student with the applications of Operations Research to business and industry and help them to grasp the significance of analytical techniques in decision making
9	**Brief Contents**	Introduction to Operation Research, Overview of how Operations Research and Analytics professionals analyse problems, Introduction to Linear Programming Solving Linear Programming problems: The Simplex method, The Theory of the Simplex Method, Duality theory, Linear Programming under Uncertainty, Other Algorithms for Linear Programming, The Transportation and Assignment problems Network Optimization models Dynamic Programming, Integer Programming, Nonlinear Programming, Metaheuristics, Game Theory, Decision Analysis, Queueing Theory, Inventory Theory, Markov Decision Processes, Simulation
10	**Contents for lab**	No

1	**Programme**	MBA
2	**Semester**	II
3	**Type of course**	Core
4	**Code of the subject**	MS615
5	**Title of the subject**	Artificial Intelligence and Machine Learning
6	**Any prerequisite**	Statistics, linear algebra, matrix, probability, programming languages and data modelling.
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Upon course completion, students will be able to: Identify problems that are amenable to solution by AI methods, and which AI methods may be suited to solving a given problem. Formalize a given problem in the language/framework of

		different AI methods. Implement basic algorithms using basic machine learning libraries mostly in python. Gain hands-on experience in applying ML to problems encountered in various domains. Obtain exposure to high-level ML libraries or frameworks such as TensorFlow, PyTorch.
9	**Brief Contents**	Introduction to AI: Definitions, Historical foundations, Basic elements of AI, Characteristics of intelligent algorithm, AI application areas, Neural network representation, Neural networks as a paradigm for parallel processing, Linear discrimination, Gradient descent, Logistic discrimination, Perceptron, Training a perceptron, Multilayer perceptron, Back propagation algorithm, Recurrent networks, Dynamically modifying network structure, Basic concepts, Hypothesis space search, Genetic programming, Models of evolution and learning, Parallelizing genetic algorithms, State space search, Production systems, Search space control: depth-first, breadth-first search, Heuristic search - hill climbing, Best-first search, Branch and Bound, Problem reduction, Constraint satisfaction end, Means-end analysis, Need of machine learning, Types of machine learning, Supervised learning: k-nearest neighbours, Linear regression, Logistic regression, Classification, Support vector machines, Neural networks, Unsupervised learning: clustering (k-means, hierarchical, EM), Auto-encoders, Dimensionality reduction, Learning by agents, Intelligent agent, Online learning, Batch learning, Markov Decision Processes, Temporal difference learning, Dynamic programming, Hyperparameters, Deep learning, Optimization techniques.
10	**Contents for lab**	Use Python/Jupyter notebooks/ google Colab for programming and hand out assignments Machine learning platforms: TensorFlow, Scikit-Learn etc. It may be good to have both theory and programming components in the assignment/homework component, to allow students to appreciate and learn both aspects of AI and machine learning

1	**Programme**	MBA/IMG
2	**Semester**	II/VIII
3	**Type of course**	Core
4	**Code of the subject**	MS616
5	**Title of the subject**	Project Management
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Students will be able to understand to manage the scope, cost, timing, and quality of the project, as defined by project

		stakeholders. Align the project to the organization's strategic plans and business justification throughout its lifecycle. Identify project goals, constraints, deliverables, performance criteria, control needs, and resource requirements in consultation with stakeholders. Implement project management knowledge, processes, lifecycle and the embodied concepts, tools and techniques in order to achieve project success. Apply project management practices to the launch of new programs, products, and services
9	**Brief Contents**	Introduction to Project Management: Concept of a project; categories of project, project development cycle, tools & techniques of project management, forms of project organizations, project management theory, various stages of planning, designing and managing projects, Development of Project Matrices, Critical Success factors and key performance indicators, Project Organization, Scheduling & Planning: Project Elements, Work Breakdown Structure (WBS), Types of WBS, Functions, Activities and Tasks, Project Life Cycle and Product Life Cycle, Project schedule, Scheduling Objectives, Building the project schedule, Scheduling terminology and techniques, Network Diagrams: PERT, CPM; Bar Charts, Milestone Charts, Gantt Charts, Estimating Project Costs and Project Selection: Estimation of activity and project costs, means of financing, financial projections, Qualitative and Quantitative Methods of Project identification and selection, Developing the Project Schedule: Activity Sequencing, Precedence Network Diagram, Project Resource levelling and allocation in projects, network techniques and timelines, crashing of projects: time vs. cost trade-off, Program Evaluation and Review Technique, Critical Path Method, Project Scheduling, Basics of Scheduling, project management tools, Project Execution and Control: Assessing and managing costs and gains, crashing of projects: time vs. cost trade-off, earned value method, Managing Project Risks: Probabilistic aspects of projects; risk management; Principles &Concepts of project Risks Management, Risk Assessment, Risk control; critical chain project management.
10	**Contents for lab**	No

1	**Programme**	IMG
2	**Semester**	VII
3	**Type of course**	Core
4	**Code of the subject**	MS617

5	**Title of the subject**	Business Data Mining
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Extract knowledge using data mining techniques. Explore recent trends in data mining such as web mining, spatial-temporal mining. Be acquainted with the tools and techniques used for Knowledge Discovery in Databases.
9	**Brief Contents**	Data Mining Concepts, Knowledge Representation, Supervised Learning framework, Concepts & hypothesis, Training & Learning, Types of Data, Data mining functionalities, Classification of data mining systems, Data mining task primitives, Data cleaning, Data integration & transformation, Data reduction, Mining Business data patterns, Associations and Correlations, Mining methods, Mining various kinds of association rules, Correlation analysis, Constraint based association mining, Classification and prediction, Basic concepts, Decision Tree induction, Bayesian classification, Rule based classification, Classification by back propagation, Support vector machines, Associative classification, Lazy learners, Other classification methods, Cluster analysis, Types of data, Categorization of major clustering Methods, K-means partitioning methods, Hierarchical methods, Density-based methods, Grid based methods, Model-based clustering methods, Clustering high dimensional data, Constraint based cluster analysis, Outlier analysis, Mining trends and business application of data
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	I/VII
3	**Type of course**	Core
4	**Code of the subject**	MS618
5	**Title of the subject**	Strategic Management
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	After the completion of this course students will be able to understand the organization and the environment in which it functions and competes. The student should be able to integrate acquired knowledge of other functional areas with the body of the knowledge of strategic management and be able to deploy all as a unified tool to analyse and formulate the actions that shall deliver the intended results.

9	**Brief Contents**	Concept of strategy and strategic management, Difference between corporate planning and strategic planning, Strategic management model, Different levels of strategies, Relevance of strategic management in 21st century, Strategic intent-vision and mission statement, Organisational objectives, Setting objectives, Organisational values and its impact, External and internal Environment and analytical tools- evaluating the company's strategic environment, SWOT analysis, PESTEL analysis, Competitive analysis, Porter's five force model, Internal Assessment- strategic capability: fit and stretch concept, Porter's value chain analysis, Core competencies, Organisational capabilities, Resource analysis and synergy, Strategies in action- Functional level- Achieving superior efficiency- Economics of scale, Experience curve, Just-in-Time, Six-sigma, Business level-cost leadership, Differentiation & focus strategies, Growth strategies, Corporate level- integration, Diversification, Acquisition, Mergers & joint venture, Short term corporate strategies-stability, Retrenchment, and turnaround, Portfolio and other analytical models- BCG matrix, GE/McKinsy matrix, Corporate parenting, Evaluation of strategy- suitability, Acceptability, and feasibility, Implementing strategies-resource allocation, Structure and strategy, Organisation culture, Balance score card.
10	**Contents for lab**	No

1	**Programme**	MBA
2	**Semester**	III
3	**Type of course**	Core
4	**Code of the subject**	MS619
5	**Title of the subject**	Entrepreneurship and Innovation
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Course is designed for preparing students to take of Entrepreneurial journey on the basis of innovative ideas. The content is highly focused to start venture to making business mature up-to international level.
9	**Brief Contents**	Entrepreneurship, Creativity and innovation, Business planning process, Institutions supporting entrepreneurs, Family businesses, International entrepreneurship opportunities, Informal risk capital and venture capital, Managing growth.
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	III/IX
3	**Type of course**	Core
4	**Code of the subject**	MS620
5	**Title of the subject**	Business Process Management
6	**Any prerequisite**	Courses on functional areas of management
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Upon successful completion of the course, student should be able to: Describe and evaluate the development of process management and tasks of process holders in organizations. Assess the importance of the strategic perspective of business process management. Analyse and model strategic and operational business processes. Employ process performance indicators and measures.
9	**Brief Contents**	Orientation: Process perspective, Components of processes, Evolution of processes, Process life-cycle, Process identification, Process architecture, Process selection, Process modeling: Introduction to BPMN, Business objects, Process decomposition, Process Discovery: Process discovery, Methods, Process modeling, Process model quality assurance, Process Analysis: qualitative process analysis, Value-added analysis, Waste analysis, Stakeholder analysis, Root-cause analysis, Quantitative process analysis: flow analysis, Queues, Simulation, Process redesign, Transactional methods, Transformational methods, Process aware information systems: Types of process aware information systems, Process implementation with executable models, Process monitoring, Process as enterprise capability
10	**Contents for lab**	BPMN modeling software (open source) for modeling of processes

1	**Program**	MBA/ IMG/
2	**Semester**	III/IX
3	**Type of course**	Core
4	**Code of the subject**	MS621
5	**Title of the subject**	Business Ethics and Sustainability
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Upon course completion, students will be able to: Develop skills in recognizing and analysing ethical issues. Define cross cultural variations and similarities in organizational practices in corporate social responsibility and business ethics. Understand sources of organizational ethical culture and to design ethical programs

		designed to accomplish specific objectives in organizations. Develop ethical leadership skills and practices
9	**Brief Contents**	Business ethics- an overview, Concepts and theories of business ethics, Emerging business ethics issues, Ethical decision making in business, Creating an ethical organization globalization and business ethics, Stakeholders and business ethics, Social responsibility and ethics, Issues in social responsibility, Implementing stakeholders' perspective, Stakeholder and issue management approaches, Managing corporate responsibility with external stakeholders, Corporate governance and ethical leadership, Kohlberg's six stages of moral development, Levels of ethical analysis, Concept of corporate integrity, Issues in corporate governance, good corporate governance - obligations towards society and stake holders, Ethics in consumer protection, Role of government agencies, SEBI, judiciary in ensuring ethical practices, Ethics and Indian business, Marketing ethics, Ethics in human resource management, financial management, banking and insurance.
10	**Contents for lab**	No

1	**Program**	MBA/ IMG/
2	**Semester**	III/IX
3	**Type of course**	Core
1	**Code of the subject**	MS621
2	**Title of the subject**	Cloud Computing and Services
3	**Any prerequisite**	Basic understanding of computer system
6	**Will this course require visiting faculty**	No
4	**L-T-P**	3-0-0
7	**Learning Objectives of the subject (in about 50 words)**	Upon course completion, students will be able to: 6. Understand cloud computing and memorize the different cloud service and deployment models. 7. Describe the concerns of storage, processing, parallelism, distribution, consensus, and scalability as they relate to the cloud 8. Learn about the different levels of clouds services, which include IaaS (Infrastructure as a Service), PaaS (Platform as a Service), SaaS (Software as a Service), FaaS (Function as a Service (server-less architecture)), MBaaS (Mobile Backend as a Service (server-less architecture)), and Amazon Lambda. 9. Learn about many types of cloud-based storage services, including object storage, block-level storage, archival storage, and Big Data file systems.

		10. Become familiar with the key concepts underlying Big Data and data streaming applications on the Cloud.
8	**Brief Contents (module wise)**	**Module-I: Introduction** Introduction, Foundations of cloud computing, Big Clouds (such as the AWS Cloud, Google Cloud, Microsoft Azure Cloud, or IBM Cloud) via portals, APIs, and SDKs, Cloud Computing characteristics (e.g., elasticity, multi-tenancy, on-demand access, ubiquitous access, usage metering, self-service capability, SLA-monitoring), Cloud Computing and Service Oriented Architecture (SOA), Cloud Service Models/Types (i.e., Public, Private, Hybrid, and Community), Cloud deployment models (i.e., IaaS, PaaS, SaaS, and BPaaS), Cloud Return on Investment (ROI) models, Cloud Reference Architectures, Cloud Standards (e.g., OSDIAPIs), Technology Providers vs. Cloud providers vs. Cloud vendors, Planning Cloud transformations **Module-II: Cloud Storage Services** Storage models and storage as a service, Using Amazon Cloud Storage Services via Portal and APIs, Using Microsoft Azure Cloud Storage Services via Portal and APIs, Using Google Cloud Storage Services via Portal and APIs, Using IBM Cloud Storage Services via Portal and APIs, Using OpenStack Cloud Storage Services via Portal and APIs **Module-III: Cloud Networking Services and Service Platform Design** Virtual Private Cloud Networking, High-Performance, Scalable Load Balancing, Cloud API Gateways, Global Content Delivery Networks, Cloud-Managed High-Performance Network Address Translation, Network Edge Connectivity, Reliable, Resilient, Low-Latency DNS Serving on the Cloud, Network Performance and Availability Optimization on the Cloud, Big Cloud Service Platforms Convergence and Service Offerings (Amazon AWS, Google GCP, Microsoft Azure, IBM Cloud, Force.com Cloud, Clouds at SGI, NASA, and CERN) **Module-IV: Cloud Platforms in Industry** Cloud platforms in industry, amazon web services, compute services, storage services, communication services, additional services, google AppEngine, architecture and core concepts, application life-cycle, cost model, observations, Microsoft Azure, Azure core concepts, SQL Azure, Windows Azure platform appliance, scientific applications, healthcare: ECG analysis in the cloud, cancer diagnosis, cloud machine learning services, business and consumer applications, CRM and ERP, productivity, social networking, media applications, multiplayer online gaming.

9	**Contents for lab (If applicable)**	• Learn how to access the Cloud via Big Cloud vendors' websites, and their APIs/SDKs; install Python, Anaconda, and Jupyter to run lab notebooks as applicable. • Create a virtual machine on the various Big Clouds using both the Portals and the applicable python libraries. • It may be good to have both theory and programming components in the assignment/Lab component, to allow students to appreciate and learn various aspects of cloud computing

1	**Programme**	MBA/IMG
2	**Semester**	Odd
3	**Type of course**	Elective
4	**Code of the subject**	MS001
5	**Title of the subject**	Digital Production System
6	**Any prerequisite**	Operations Management
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Upon successful completion of the course, student should be able to: Appreciate role of digital manufacturing. Analyse various computing models. Employ information and communication technologies for design of digital production systems.
9	**Brief Contents**	Science of digital manufacturing: operation mode and architecture of digital manufacturing system, Modeling theory and method of digital manufacturing science, Theory system of digital manufacturing science, Computing manufacturing in digital manufacturing science: computing manufacturing methodology, Manufacturing computational model, Theoretical units in manufacturing computing, Manufacturing informatics in digital manufacturing science: Principal properties of manufacturing information, Measurement, Synthesis and materialization of manufacturing information, Integration, sharing and security of manufacturing information, Intelligent manufacturing in digital manufacturing science: Intelligent multi-information sensing and fusion in the manufacturing process, Knowledge engineering in the whole life cycle of manufacturing product, Autonomy, Self-learning, Adapting of manufacturing system, Intelligent manufacturing system
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Even
3	**Type of course**	Elective

4	**Code of the subject**	MS002
5	**Title of the subject**	IT Products and Intellectual Property Rights
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	The course is designed to impart the value driven IT products development including software, and firmware/hardware of different industrial requirements. Through understanding of the Intellectual property rights, the learner acquaint with the protection of new IT product from business threat.
9	**Brief Contents**	Industry Need analysis for IT product development, The Design thinking for new IT product development, Tools and Techniques of IT product development, Software design analysis, Firmware design, Product prototyping, Value analysis, Intellectual property rights for Software and Firmware, Industry-Market fit performance, Evaluation of product
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Odd
3	**Type of course**	Elective
4	**Code of the subject**	MS003
5	**Title of the subject**	Management of Digital Technologies
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	The course has been designed to provide comprehensive and in-depth coverage of all important aspects of modern digital technologies on the principle of industrial applications to maximize the efficiency, effectiveness and business performance. It is primarily intended for students who wish to pursue a career in mapping industrial design on the digital system.
9	**Brief Contents**	Introduction of Industry 4.0. Business System engineering and Management through Digital Technologies, Digital Transformation and Business Transition to industrial revolution 5.0. Concepts of Industry 5.0-sustainability, human centricity and system resilience through digital technologies, Understanding Blockchain principles, technology and its applications, Introduction of sensory inputs, data acquisition and applications, Introduction of Business data cloud and management, Human-system interface concept, principles, and design, Introduction of Cyber Physical System and understanding design cases
10	**Contents for lab**	No

1	**Program**	MBA/IMG
2	**Semester**	Even
3	**Type of course**	Elective
4	**Code of the subject**	MS004
5	**Title of the subject**	Knowledge Management
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Develop an integrated and comprehensive perspective of knowledge management as a strategic function. Identify the strategic contexts of knowledge management and the role of organisational structure and processes. Discuss the frameworks, techniques, and the nature of IT support for managing knowledge. Delineate the role of innovations in knowledge creation. Raise and resolve issues in knowledge protection for sustaining competitive advantage. Provide a platform for sharing experiences in knowledge management.
9	**Brief Contents**	The Nature of knowledge: Introduction to knowledge management, The nature of knowing, Leveraging knowledge, Intellectual capital, Strategic management perspectives, Creating knowledge, Organisational learning, The learning organisation, Knowledge management tools and systems, Knowledge management tools: component technologies, Knowledge management systems, Mobilising knowledge, Enabling knowledge contexts and networks, Implementing knowledge management.
10	**Contents for lab**	Case study exercises

1	**Programme**	MBA/IMG
2	**Semester**	Odd
3	**Type of course**	Elective
4	**Code of the subject**	MS005
5	**Title of the subject**	Service-Oriented Computing
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Service delivery lifecycle and associated phases. Analysis and conceptualization of services and micro-services. Service design through web. Modern service APIs and contract versioning techniques for web services
9	**Brief Contents**	Introduction of Service Oriented Architecture design and development , Case examples and case descriptions, Understanding Service-Orientation- Business Automation, Design paradigm, Design principles, Silo-based application architecture, Effects of service-orientation on the enterprise, Service-orientation and the concept of application and

		integration, The Service composition, Goals and benefits of Service-Oriented computing, Four pillars of Service-orientation, Understanding SOA- The Four characteristics of SOA: Business-driven, Vendor-neutral, Enterprise-centric, Composition-centric, Design priorities; The Four common types of SOA, The End result of Service-orientation and SOA, SOA Project delivery strategies, SOA project stages, SOA adoption planning, Service inventory analysis, SOA modelling, Contract, Logic design, Service development, Testing, Deployment and maintenance, Usage and monitoring, Understanding layers with services and micro services, Analysis and modelling with Web services and Micro services, Analysis and modelling with REST services and Micro services
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Even
3	**Type of course**	Elective
4	**Code of the subject**	MS006
5	**Title of the subject**	Social Networks Analytics
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	The main learning objective with this course is to enable students to put Social Network Analysis projects into action in a planned, informed and efficient manner. This overarching goal involves the following subtasks: Formalize different types of entities and relationships as nodes and edges and represent this information as relational data .Plan and execute network analytical computations. Use advanced network analysis software to generate visualizations and perform empirical investigations of network data. Interpret and synthesize the meaning of the results with respect to a question, goal, or task. Collect network data in different ways and from different sources while adhering to legal standards and ethics standards.
9	**Brief Contents**	Overview on network analysis, The Network analysis process and methodology, Network visualization, When images do not suffice: Network analytical measures, Models and simulation of network evolution, Models and simulation of diffusion in networks, Subgroups and cliques clustering, Block models, Ego networks, Reciprocity, Social capital, structural holes, equivalence; Network Data: Ethics, Privacy, Legality, Introduction: Using text data for network analysis, natural Language Processing and Relation Extraction from Texts

		Construct: A model of meta-network dynamics, Usage of network analysis for investigating crime, Relational methods for analysing covert networks
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Odd
3	**Type of course**	Elective
4	**Code of the subject**	MS007
5	**Title of the subject**	Software Project Management
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	The students will be able to understand the principles of project management. Comprehend the fundamental principles of project management, including project planning, scheduling, resource allocation, and risk management. Develop a project plan that includes a work breakdown structure, critical path analysis, resource allocation, budgeting and time management.
9	**Brief Contents**	Introduction and Software Project Planning: Fundamentals of software project management (SPM), Need identification, Vision and scope document, project management cycle, SPM objectives, Management spectrum, SPM framework, Software project planning, Planning objectives, Project plan, Types of project plan, Structure of a software project management plan, Software project estimation, Estimation methods, Estimation models, Decision process, Project Organization and Scheduling: Project Elements, Work Breakdown Structure (WBS), Types of WBS, Functions, Activities and Tasks, Project Life Cycle and Product Life Cycle, Ways to Organize Personnel, Project schedule, Scheduling objectives; Building the project schedule, Scheduling terminology and techniques, Network Diagrams: PERT, CPM, Bar Charts: Milestone Charts, Gantt Charts, Project Monitoring and Control: Dimensions of Project Monitoring & Control, Earned Value Analysis, Earned Value indicators: Budgeted Cost for Work Scheduled (BCWS); Cost Variance (CV), Schedule Variance (SV), Cost Performance Index (CPI), Schedule Performance Index (SPI), Interpretation of Earned Value Indicators, Error Tracking; Software Reviews, Types of Review: Inspections, Deskchecks, Walkthroughs, Code Reviews, Pair Programming, Software Quality Assurance and Testing: Testing Objectives, Testing Principles, Test Plans, Test Cases, Types of Testing, Levels of Testing, Test strategies, Program correctness, Program verification & validation, Testing automation & Testing tools, Concept of Software quality;

		Software quality attributes; Software Quality Metrics and indicators; The SEI Capability Maturity Model CMM), SQA activities, Formal SQA Approaches: Proof of correctness, Statistical quality assurance, Cleanroom process, Project Management and Project Management Tools: Software Configuration Management: Software Configuration items and tasks; Baselines; Plan for Change, Change control, Change Requests management, Version Control; Risk management: Risks and risk types, Risk Breakdown Structure (RBS); Risk Management process: Risk identification, Risk analysis, Risk planning, Risk monitoring; Cost Benefit analysis; Software Project management tools: CASE tools, Planning and Scheduling tools, MS-Project.
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Even
3	**Type of course**	Elective
4	**Code of the subject**	MS008
5	**Title of the subject**	Software Quality Management
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Students will be able to develop a comprehensive understanding of the concepts and practices related to software quality management. Gaining knowledge of software quality standards, testing techniques, and software metrics. Evaluate the effectiveness of quality management strategies, such as continuous improvement, risk management, and quality assurance.
9	**Brief Contents**	Introduction to Software Quality: Defining Software Quality, Software quality, Attributes and specification, Cost of quality defects, faults, failures, Defect rate and reliability, Defect prevention, Reduction and containment, Overview of different types of software review, Introduction to measurement and inspection process, Documents and metrics, Software Quality Metrics: Product Quality Metrics: Defect density, Customer problems metric, Customer satisfaction metrics, Function points, In-process quality metrics: Defect arrival pattern, Phase-based defect removal pattern, Defect removal effectiveness, Metrics for software maintenance: Backlog management index, Fix response time, Fix quality, Software quality indicators, Software Quality Management and Models: Modeling process, Software reliability models: The Rayleigh model, Exponential distribution and Software reliability growth models, Software reliability

		allocation models, Criteria for model evaluation, Software quality assessment models: Hierarchical model of software quality assessment.Software Quality Assurance: Quality Planning and Control, Quality improvement process, Evolution of software quality assurance SQA, Major SQA activities, Major SQA issues, Zero defect software, SQA techniques, Statistical quality assurance, Total quality management, Quality standards and processes, Software Verification, Validation & Testing: Verification and validation, Evolutionary nature of verification and validation, Impracticality of testing all data and paths, Proof of correctness, Software testing, Functional, structural and Error-oriented analysis & testing, Static and dynamic testing tools, Characteristics of modern testing tools.
10	**Contents for lab**	No

1	**Program**	MBA/IMG
2	**Semester**	Even
3	**Type of course**	Elective
4	**Code of the subject**	MS009
5	**Title of the subject**	Programming for Business Intelligence
6	**Any prerequisite**	None
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Upon course completion, students will be able to: Derive actionable insights from data, thus allowing to make data-driven, strategic and tactical business decisions. Design and implement an algorithm to conduct technical calculations, manipulate data and create graphical user interfaces. Identify the technological architecture that makes up Business Intelligence systems
9	**Brief Contents**	Business Intelligence (BI): Effective and timely decisions, Data, Information and knowledge, Role of mathematical models, BI architectures, Ethics and BI, Decision support systems: definition of system, Representation of the decision-making process, Definition of decision support system, Development of a decision support system, Customer Relationship Management (CRM), ERP, and BI, Importance of data and relevance in industry, Statistical learning vs. machine learning, Types and phases of analytics, Data pre-processing and cleaning: data manipulation steps, Normalizing data, Sampling, Missing value treatment, Outliers, Exploratory data analysis: data visualization using matplotlib, Seaborn libraries, Creating graphs, Summarizing data, Descriptive statistics, Univariate analysis, Bivariate analysis, Querying and reporting, Building Ad-Hoc queries, Building on-demand self-service reports, Enhancing and modifying data access, Pull-oriented data access, Push-oriented data access dashboards, Executive Information System (EIS) engine, Metric system and KPIs, business intelligence

		dashboards, Learning SQL query structure with examples, Data management and query system OLTP and OLAP and their data models, Data warehousing, ETL and data integration dashboard creation using Tableau, Power BI, The relevance of BI in application to analytics industry and different domains such as marketing models: relational marketing, Sales force management, Logistic and production models: supply chain optimization, Optimization models for logistics planning, Revenue management systems.
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Even
3	**Type of course**	Elective
4	**Code of the subject**	MS010
5	**Title of the subject**	Strategic Planning of Information Systems
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	The strategic use of information systems as a means for acquiring competitive advantage. Integration of concepts and methodologies with skills acquired in the field of information systems and technology in the development of a comprehensive information systems prototype. Measurable benefits in the alignment of business processes with information systems solutions. The course provides students with the opportunity to apply systems concepts and techniques in the design of an information system.
9	**Brief Contents**	Introduction to strategic information systems , Business environment issues, The process of strategic information systems , Current business situation analysis , Identify an opportunity , The role of business information systems , Information systems strategies , Strategic information systems management, Organization of the information systems technologies , Software , Hardware, Database , Communications ,Networking , Evaluation of possible IS solutions, Project Management, Cost Benefit Analysis, Functional requirement, System specifications , Information systems benefits , Strategic information management , Managing the information resource
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Odd
3	**Type of course**	Elective
4	**Code of the subject**	MS011
5	**Title of the subject**	Business Systems Simulation
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Understanding the principles and techniques of simulation modeling for business systems. Understanding the key components of a business system and how they interact with each other. Learning how to analyse and interpret simulation results to make informed decisions. Understanding the limitations of simulation modeling and the assumptions that need to be made. Learning how to optimize simulation models to achieve business objectives. Understanding the ethical implications of simulation modeling and the importance of data privacy and security. Learning how to apply simulation modeling in different industries and applications, such as manufacturing, logistics, healthcare, finance, and customer service.
9	**Brief Contents**	Introduction to Business System Simulation: Overview of the benefits of simulation modeling, The various types of simulation models, and the different tools and software used for simulation modelling, System Dynamics: Modeling approach on the feedback loops and dynamic relationships between different variables in a system, Topics covered include stock and flow diagrams, feedback loops, and system dynamics models, Discrete-Event Simulation: Modeling the discrete events and processes that occur in a system, such as customer arrivals, order processing, and inventory movements, Topics covered include event scheduling, process modeling, and queuing theory, Agent-Based Simulation: Modeling individual agents or entities within a system, such as customers, employees, or machines. Topics covered include agent behaviour modeling, agent interactions, and emergent behaviour, Optimization and Analysis: Various techniques used to optimize a simulation model and analyse the results, including sensitivity analysis, scenario analysis, and statistical analysis. Applications of Business System Simulation: Case studies and examples of how simulation modeling is used in different industries and applications, such as manufacturing, logistics, healthcare, finance, and customer service.
10	**Contents for lab**	No

1	**Programme**	MBA/IMG

2	**Semester**	Even
3	**Type of course**	Elective
4	**Code of the subject**	MS012
5	**Title of the subject**	Service Operations Management
6	**Any prerequisite**	Operations Management
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Upon successful completion of the course, student should be able to: Define services along with their nature and classification. Assess factors related to location and capacity planning. Employ design principles in development of service delivery systems. Analyse requirements to ensure maintainability and reliability in services.
9	**Brief Contents**	Matrix of service characteristics, Taxonomy of services, Challenges in operations management of services, Aggregate capacity planning for services, Facility location, Subjective and objective factors, Service design and delivery systems, layouts in services, Job and work design in services-safety and physical environment, Effect of managing queues, Automation, Operations standards and work measurement, Determinants of quality in services, Measurement, control and improvement of quality of services, Concept of a total quality service, Dynamics of service delivery system, Scheduling for service operations, Personnel and vehicles, Supply chain and distribution of services, Maintainability and reliability in services, Total productive maintenance (TPM) in services, Case studies of exemplary professionally managed services.
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Odd
3	**Type of course**	Elective
4	**Code of the subject**	MS013
5	**Title of the subject**	Sustainable Supply Chain Management
6	**Any prerequisite**	Operations Management
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Upon successful completion of the course, student should be able to: Develop an understanding of the role of supply chain in an overall value creation. Analyse different modes of transportation, different design options of transportation network in a supply chain, their applicability under different contexts and the trade-offs in transportation design. Describe the importance of reverse logistics in market places as well as market spaces. Design sustainable supply chains.

9	**Brief Contents**	Evolution of SCM, Issues of SCM, Competitive strategy vis-à-vis supply chain strategy, Achieving strategic fit, Managing inventory in a supply chain, Deterministic models, Probabilistic models (multi-period and single period). Managing risk and uncertainty in a supply chain: quick response strategy, Postponement strategy, Tailored sourcing strategy, Transportation in a supply chain: role of transportation in a supply chain, Modes of transportation and their performance characteristics, Design options for a transportation network, Trade-offs in transportation design, Supply chain coordination: Bullwhip effect - causes and consequences, Bullwhip effect quantification, Impact of centralized information on bullwhip effect, Mitigating strategies, Information sharing and incentives, Strategic sourcing in SCM: Role of sourcing in a supply chain, Framework for make/buy decisions, Supplier scoring and assessment, Supply contracts and supply chain performance, Big data analytics in SCM: Significance of big data in supply chain, Relevant tools, Reverse logistics: Reverse logistics in manufacturing organizations and ecommerce firms.
10	**Contents for lab**	SCM software like SAP SCM, Logility, Perfect Commerce, Oracle SCM etc.

1	**Programme**	MBA/IMG
2	**Semester**	Even
3	**Type of course**	Elective
4	**Code of the subject**	MS014
5	**Title of the subject**	Technology Management
6	**Any prerequisite**	Operations Management
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Upon successful completion of the course, student should be able to: Define types of innovation, innovators and innovation environment. Describe the nature and extent of technological change and potential roles of incremental and disruptive innovation in creating and sustaining firm competitiveness. Perform feasibility and viability of new product development proposal from various perspectives.
9	**Brief Contents**	Introduction, Understanding innovation, Levels and types of innovation, Key drivers of innovation, Sources of innovation, and the relationship between innovation and research and technology development. understanding creativity as a building block to innovation, Innovation management, Framework for the management of innovation, Public sector services innovation, Diffusion of innovation creating organizational innovative

		effectiveness, Strategic aspects of technology, Critical factors in managing technology innovations, Critical issues/factors in choice of technology and processes; Indian context, Technology portfolio, Open innovation, New technology transfer-channels, Modes, Levels and issues, Absorption, adaption and adoption of technology, Technology considerations in lean environment, Strategic role of R&D, New R&D approaches, Strategic evaluation of technology investments, New product development and life cycle management, Understanding product platform strategy, Commercialization of core competencies, Marketing new products and technologies, Role, rationale and requisites of a national technology policy, IPR and licensing issues, Role of WTO.
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Odd
3	**Type of course**	Elective
4	**Code of the subject**	MS015
5	**Title of the subject**	Technology and Operations Strategy
6	**Any prerequisite**	Operations Management
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Upon successful completion of the course, student should be able to: Appreciate the nature, need and scope of operations strategy. Describe the strategic role of transformation processes and associated flows. Develop and analyse innovation, new product and process development strategies. Employ process of operations strategy in terms of sustainable alignment.
9	**Brief Contents**	Need for Operations Strategy, Impact of globalization on Operations Management, The Marketing link in the Operations Strategy -Role in competitive advantage, Time-based competitiveness and other criteria of success, The Sandcone model, Process of designing, analysing and implementing operations' strategies, Strategic management of transformation processes and flow strategies, Strategic choices in layout and capacity planning, Managing innovations and new product and process development strategies, Strategic purchasing and supply management, Outsourcing decisions, Strategic Purchasing Portfolio analysis, Operations improvement strategies, Breakthrough vs. continuous, The direct, Develop and deploy strategies, The market strategy, Bohn's stages of process matrix, Measures of performance, Process of Operations strategy, Sustainable alignment, Methodology of operations strategy formulation, Process of operations strategy formulation, Integrated management systems
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Even
3	**Type of course**	Elective
4	**Code of the subject**	MS016
5	**Title of the subject**	Total Quality Management
6	**Any prerequisite**	Basic Knowledge of Probability and Statistics
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	This course provides learners with an understanding of quality control and improvement systems. This course will help participants to: Understand the principles of total quality management. Choose appropriate statistical techniques for improving processes. Develop the organizational, competitive and economic potential of quality. Integrate fundamental principles with the practice of total quality management.
9	**Brief Contents**	Evolution and Importance of Total Quality Management: Introduction, Importance of Quality, Evolution of Quality, What is Total Quality Management, Quality Pioneers, Active Living and Health Environment for TQM: Quality Leadership and Management Commitment, Employee Empowerment, Organizational Culture and Change, Team Building, TQM Infrastructure: Supplier relation and partnership, Continuous Improvement process lesson, Developing TQM action plan, TQM and Other Continuous Improvement Systems: Quality Standards, Six Sigma, Benchmarking, Just in Time, Stabilizing and Improving a Process: Defining and Documenting a Process, Diagnosing and Improving a Process, Statistical Process Control, Variables and Attributes Charts, The Fork Model For Quality Management- Management's Commitment to Transformation Lesson, Education and Daily Management, Cross-Functional Management, Quality Policy Management
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Odd
3	**Type of course**	Elective
4	**Code of the subject**	MS017
5	**Title of the subject**	World Class Production Systems
6	**Any prerequisite**	Operations Management
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Upon successful completion of the course, student should be able to: Appreciate the concept and need of world class manufacturing. Employ frameworks of various product and

		process design structures and systems in modern manufacturing. Analyse the implementation of TQM, JIT and Theory of Constraints. Appreciate philosophy and principles of Japanese manufacturing especially Toyota Production System (TPS).
9	**Brief Contents**	World Class Manufacturing (WCM): Concepts and Evolution, Understanding the linkage between Operations Strategy and WCM, Agile Manufacturing: Distinction between flexibility and agility, Model for implementing flexible and agile manufacturing, Flexible Manufacturing System (FMS), Concepts and components, Modern product and process design concepts and considerations, Assembly lines and batch manufacturing; group technology (GT), Total Quality Management (TQM): Roadmap to Implementation of TQM in manufacturing, Six Sigma approach, Just-in-Time (JIT) and Lean Operations, Theory of constraints (ToC), Japanese manufacturing techniques particularly Toyota Production System, Japanese vs American manufacturing focus, Critical elements of JIT, Operational Framework for concurrent implementation of TQM and JIT, Total Productive Maintenance (TPM): Concepts and Evolution, Metrics of TPM, Overall Equipment Effectiveness (OEE), Roadmap to TPM implementation in modern manufacturing, Computer Integrated Manufacturing System (CIMS): A framework for computer integrated enterprise issues involved in CIMS, Benchmarks for excellence in operational performance with global examples, Significance of implementation of concurrent operations management initiatives, Metrics of operational excellence in global context.
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Even
3	**Type of course**	Elective
4	**Code of the subject**	MS018
5	**Title of the subject**	Emerging areas in Operations and Technology Management
6	**Any prerequisite**	Operations management
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Upon successful completion of the course, student should be able to: Describe role of sustainable operations management. Design operations management along globally dispersed distributed networks. Develop nimble factories for supporting a lot size of one.

9	**Brief Contents**	Digital supply chains, Computer aided design and integrated manufacturing, A Focus on the employee experience, Flexible, blended workplace environments, Mobile communications and collaboration, Scaling production according to demand, Building the customer relationship.
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Even
3	**Type of course**	Elective
4	**Code of the subject**	MS019
5	**Title of the subject**	New Products and Services Development
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	On completion of the course, students will be able to: Describe the nature and techniques of innovation and new product development. Discuss and reflect on the role of marketing in different phases of new product development. Explain the phases and intermediate results in new product development process. Apply theories of innovation to demonstrate the best level of practice in each problem situation within the context of new product development. Develop and implement a new product strategy for an enterprise.
9	**Brief Contents**	Product Conception: Product Basics Consumer problems and unmet need Empathy, Personas, User Stories Identifying New Product Opportunities using Data Market Research for New Product Development Idea Generation & Need Analysis Concept testing using Surveys-Customer Discovery Product potentiality and Conjoint analysis Design Thinking for B2C, B2B Products and Services, Product Design: Product Design Process - 7 Stages Product specifications and features Visual Design Elements Tools for Design of Digital Products User experience (UX) design Introduction to Software Tools used to design Engineering Products Quality Function Deployment, Value engineering methodology, Iterative design optimisation, Design for manufacturing, Prototyping: What is Minimum Viable Products (MVP)? Types of MVP Hypothesis Testing, A/B Prototype development for Digital Products, Wireframing 3D Printing and 3D Cutting Material Selection for Engineering Product, Prototyping Prototype, Functionalisation using Electronics and Instrumentation, Role of Robotics and Automation in Prototyping, Usability and Beta Testing, Product Deployment: Production planning and control Material handling In-house Budgeting and Outsourcing Quality Assurance

		Protocols Principles of Lean: Lean Manufacturing and Management Regulations and Standards: ISO Intellectual Property and Trademarks Building Markets and Creating Demand for New products services, Simulated test marketing, and Launching of new products, Product Lifecycle Management: Organisation for Product Management Marketing Manager-Product Manager-Brand Manager Concept Approaches and Organisational role Product Manager-Functions and Tasks-Tools and Techniques The Product in Corporate Life, Corporate and Product Objective Product Strategy and Policy Optimum Product Pattern/Line Range Challenge Of Change-Opportunity and Risk-Product Innovation, Modification, Addition and Elimination Product Proposals-Sources, Generation, Processing and Selection Contemporary Challenges and opportunities in product Management, Product Sales and Marketing: Brand Awareness, Consumer Brand Knowledge Product-line Decisions (extension, reduction), Product Category expansion Pricing Model and Strategy Product Costing Segmentation | Target | Positioning Sales Forecasting Distribution Channels Lead Generation-Role of Contacts and social media Customer Acquisition Customer retention, Commercialisation and Start-up: Introduction to Business Model Canvas Funding Requirement and Avenues Bootstrapping Team Building and Collaborations Customers and End Users Market Competition and Creating Barriers to Entry Deployment and Distribution Strategy Launching of Start-up: Rules and Steps Social media, Websites, and Digital Marketing Scale-up model and Sustainable growth plan
10	**Contents for lab**	No

1	**Program**	MBA/IMG
2	**Semester**	Even
3	**Type of course**	Elective
4	**Code of the subject**	MS020
5	**Title of the subject**	Operational Intelligence
6	**Any prerequisite**	None
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Upon successful completion of the course, student should be able to: Describe the importance of data-driven operations along supply chains. Assess unbiased estimates of demand forecasting as well as optimization using various statistical methods. Employ mathematical models to capture and analyze data on supply chain carbon footprint.
9	**Brief Contents**	Problem-driven to Data-driven operations along supply chains, Big data in supply chain, Analytics in demand planning: Capturing

		demand data from different sources, Demand prediction models, Price optimization, Analytics in sourcing and procurement: In-house or outsource, Logistics and transportation, Supply chain contracts, Analytics in sales and operations planning: Differentiated service level to different products and customers, Location of plants, Product line mix at plants, Production planning and scheduling, Analytics in distribution: Location of distribution centre, Transportation and distribution planning, Inventory policies/order fulfilment at locations, Vehicle routing for deliveries, Analytics in reverse logistics in traditional and e-commerce firms: Location of return centres, Reverse distribution plan, Vehicle routing for returns collection, Analytics in supply chain carbon footprint
10	**Contents for lab**	Proficiency in using various software like SAS Business Analytics (SAS BA), Excel, Tableau, Microsoft Power BI etc.

1	**Programme**	MBA/IMG
2	**Semester**	Odd
3	**Type of course**	Elective
4	**Code of the subject**	MS021
5	**Title of the subject**	Compensation Management
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	The aim of this subject is to develop students' understanding of the concepts of compensation and rewards in the organization. In particular the subject is designed to develop the underpinning knowledge and skills required to understand the one of the complex management functions i.e. compensating employees and its importance. This subject introduces the student to the basics compensation structure and differentials. It familiarizes the students with the practice of various management techniques and its expected results like job evaluation etc. The learner is apprised about the latest issues in management related to compensation in order to make the students abreast about the recent trends in the area.
9	**Brief Contents**	Introduction to compensation and rewards, Objective of compensation and rewards, Introduction to framework of compensation policy, Labor market characteristics and pay relatives, Wage determination: Introduction to compensation, rewards, wage levels and wage structures, Introduction to wage determination process and wage administration rules; Introduction to factors influencing wage and salary structure and principles of wage and salaries administration, Introduction to the theory of wages: Introduction to minimum, fair and living wage, Introduction to nature and objectives of job evaluation; Introduction to principles and procedure of job evaluation

		programs, Introduction to basic job evaluation methods; Introduction to Implementation of evaluated job, Introduction to determinants of incentives, Introduction to classification of Rewards, Incentive payments and its objectives, Introduction to wage incentives in India; Introduction to types of wage incentive plans, Introduction to prevalent systems & guidelines for effectives incentive plans; Introduction to non- monetary incentives, Introduction to cafeteria style of compensation, Introduction to problems of equity and bonus, Profit sharing & stock options, Introduction to features of fringe benefits, Introduction to history and growth factors, Coverage of benefits, Introduction to employee services & fringe benefits in India
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Even
3	**Type of course**	Elective
4	**Code of the subject**	MS022
5	**Title of the subject**	Change Management
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Effective management within organizations requires an understanding of various behaviour and processes. Managers need to know why people behave as they do in relation to their jobs, their work groups and their organizations. This knowledge of individuals' perceptions, motivational attitudes and behaviour will enable managers to not only understand themselves better, but also to adopt appropriate managerial policies and leadership styles to increase their effectiveness. The major objective of this course is to provide students with a better understanding of behavioural processes and thereby enable them to function more effectively in their present or future roles as managers of human resources.
9	**Brief Contents**	Definition of Organization Development (OD), OD and planned change from other forms of organization change, Describe the historical development of OD, Describe and compare three major perspectives on changing organizations, Introduce a General model of planned change, Describe how planned change can be adopted to fit different kinds of conditions, Understand the essential character of OD practitioners, Understand the necessary competencies required of an effective OD practitioner, Understand the roles and ethical conflicts that face OD practitioners, Reinforce the definition of an OD practitioner as

		anyone who is helping a system to make planned change, Describe the steps associated with starting a planned change process, Equip students with a general framework of diagnostic tools from a systematic perspective, Define diagnosis and to explain how the diagnostic process provides a practical understanding of problems at the organizational level of analysis, Discuss criteria for effective interventions, Discuss issues, considerations, constraints, ingredients, and processes associated with intervention design, Give an overview of the various interventions, Understand the issues associated with evaluating OD interventions, Understand the process of institutionalizing OD interventions and the factors that contribute to it, Understand the importance of data feedback in the OD process, Describe the desired characteristics of feedback content, and Describe the desired characteristics of the feedback process.
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Odd
3	**Type of course**	Elective
4	**Code of the subject**	MS023
5	**Title of the subject**	Corporate Social Responsibility
6	**Any prerequisite**	None
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Upon course completion, students will be able to: Develop skills in recognizing and analysing ethical issues. Define cross cultural variations and similarities in organizational practices in corporate social responsibility and business ethics. Understand sources of organizational ethical culture and to design ethical programs designed to accomplish specific objectives in organizations. Develop ethical leadership skills and practices
9	**Brief Contents**	Business ethics- an overview, Concepts and theories of business ethics, Emerging business ethics issues, Ethical decision making in business, Creating an ethical organization globalization and business ethics, Stakeholders and business ethics, Social responsibility and ethics, Issues in social responsibility, Implementing stakeholders' perspective, Stakeholder and issue management approaches, Managing corporate responsibility with external stakeholders, Corporate governance and ethical leadership, Kohlberg's six stages of moral development, Levels of ethical analysis, Concept of corporate integrity, Issues in corporate governance, good corporate governance - obligations towards society and stake holders, Ethics in consumer protection,

		Role of government agencies, SEBI, judiciary in ensuring ethical practices, Ethics and Indian business, Marketing ethics, Ethics in human resource management, financial management, banking and insurance.
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Even
3	**Type of course**	Elective
4	**Code of the subject**	MS024
5	**Title of the subject**	Competency Management
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	The aim is to give students a better idea of how to work with their employees to make today's competency-based performance reviews more effective and a more positive experience. Begin to think of it differently: as a partnership or a collaborative effort.
9	**Brief Contents**	Introduction to competency**:** definition and history of competency, Basic components of competency (Knowledge(K), Skill(S), Attitude(A)), Performance Vs competency, Difference between competence and competency, Type of competency generic vs key competency, Functional and technical competency, Leadership and managerial competency, Need for competency framework, Limitation and learning from competency framework, Myth about competency, Competency development & its models**:** Need and importance of competency development, Stages in developing competency model, Types of competency Model – core/generic, Job specific, Managerial / leadership, Custom, development of personnel competency framework, competency mapping**:** procedures / steps-determining objectives and scope, Clarifying implementation goals and standards, create an action plan, Define competency-based performance effectiveness (key result area (KRA) & key performance indicators (KPI)), Tools for data collection, Data analysis, Validating competency model, Mapping future jobs, and single incumbent jobs, Using competency profile in HR decisions, Mapping competency for recruitment and selection, Training and development, Performance and compensation, Competency driven career and culture**:** Role of competency in career progression, Transactional competency, Tradition competency and

		transformational competency, Evaluation of career through KSA (Knowledge, Skill, and Attitude) Competency-based succession and career planning, corporate competency driven culture.
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Odd
3	**Type of course**	Elective
4	**Code of the subject**	MS025
5	**Title of the subject**	Human Resource Information System
6	**Any prerequisite**	Human Resource Management
7	**L-T-P**	3-0-1
8	**Learning Objectives of the subject**	To review and understand the basic concepts and principles of human resource information system and to apply the same to the real world. To explore strategic value of HRIS and its contribution to organizational success. To review the leading HRIS software. To explore the ways of identifying best HRIS based on industry specificity and ROI.
9	**Brief Contents**	Introduction to HRIS, Acquisition and HRIS costs, Needs Assessment; HR metrics, Database concepts and applications in HRIS, Change management and data validation, HRIS design and implementation considerations, HR administration and HRIS, Job analysis, Security and privacy issues, Emerging trends in HRIS.
10	**Contents for lab**	Case study exercises Class projects and exercises

1	**Programme**	MBA/IMG
2	**Semester**	Even
3	**Type of course**	Elective
4	**Code of the subject**	MS026
5	**Title of the subject**	Emerging Areas in Human Resource
6	**Any prerequisite**	Human Resource Management
7	**L-T-P**	3-0-1
8	**Learning Objectives of the subject**	To recap the major concepts and theories of HRM. To explore the emerging areas of HRM. To understand practical applications of theory relevant to today's workplace. To explore contemporary topics in Human Resource Management. To build strong foundation and relevant skill set required in today's workplace.

9	**Brief Contents**	Setting the hybrid work model for collaboration, Human leadership, Working in the metaverse, Managing international human resources, Managing human resources in small and medium enterprises, Strategic human resource management, Change management, People analytics, The transition from employee well-being to healthy organization, Diversity, equity and inclusion
10	**Contents for lab**	Case study exercises Class projects and exercises Role playing

1	**Programme**	MBA/IMG
2	**Semester**	Odd
3	**Type of course**	Elective
4	**Code of the subject**	MS027
5	**Title of the subject**	Organization Theory & Development
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Describe how the need to increase organizational efficiency and effectiveness has guided the evolution of management theory. Explain the principle of job specialization and division of labor, and tell why the study of person-task relationships is central to the pursuit of increased efficiency. Identify the principles of administration and organization that underlie effective organizations.
	Brief Contents	Explain what is meant by the term organization, Classify the three levels of managers and identify the primary responsibility of each group, Describe the difference between managers and operative employees. Explain the skills and roles manager, Describe the value of studying organization. Identify the relevance of popular humanities and social science courses to management practices, Trace the change in theories about how managers should behave to motivate and control employees, Explain the contributions of management science to the efficient use of organizational resources, Explain why the study of the external environment and its impact on an organization has become a central issue in management thought, Describe forces that act as stimulants to change, Summarize the sources of individual and organizational resistance to change, Summarize Lewin's three-step change model. Explain the values underlying most OD efforts, Contrast process reengineering and continuous improvement processes, Identify properties of innovative organizations**,** List characteristics of a learning organization, Describe potential sources of stress, Organizational

		Development Techniques, Explain individual difference variables that moderate the stress–outcome relationship
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Even
3	**Type of course**	Elective
4	**Code of the subject**	MS028
5	**Title of the subject**	Leadership & Talent Management
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Leadership and Talent Management primarily focus on managerial leadership as opposed to parliamentary leadership or emergent leadership in informal groups. The objective of this module is to present the theory and research on leadership and talent management in formal group.
9	**Brief Contents**	Define leader and explain the difference between managers and leaders, Summarize the conclusions of trait theories of leadership, Describe the Fiedler contingency model, Summarize the path goal model of leadership, Explain situational leadership, Identify the qualities that characterize charismatic leaders and authentic leaders, Meaningof talent, Talent or human capital of an organization, Why talent/human capital management? Functions of talent management**.**
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Odd
3	**Type of course**	Elective
4	**Code of the subject**	MS029
5	**Title of the subject**	Training & Development
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	To develop an understanding from the point of view of the individual employee. Improve the individual's level of awareness. Increase an individual's skill in one or more areas of expertise. Increase an individual's motivation to perform their job well.
9	**Brief Contents**	Overview of training, Trends in training, Career opportunities in training important concepts and meanings, Why conduct a training needs analysis, When to conduct a TNA, The TNA model, The framework for conducting a TNA, Output of TNA,

		Approaches to TNA, Introduction to the design of training organizational constraints developing objectives, Why use training objectives, Overview of the training design ,Matching methods with outcomes , Lectures and demonstrations , Games and simulations, On-the-job & off the job training, Development of training, implementation, transfer of training. Evaluation of training, Rationale for evaluation, Resistance to training evaluation
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Even
3	**Type of course**	Elective
4	**Code of the subject**	MS030
5	**Title of the subject**	Management of Employee Relations
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	To develop an understanding of the interaction pattern among labour, management and the State. To build awareness of certain important and critical issues in Industrial relations. To impart basic knowledge of the Indian Industrial relations system and its distinctive features.
9	**Brief Contents**	The evolution of Industrial relations, understand the scope and objectives of Industrial relations, Essential of Industrial relations, participants of Industrial relations and dynamics of their participation, perspective and approach, The system of industrial relation in India, the historical perspective of Industrial relations, Describe the trends in Industrial relations management, The changing characteristics of Industry and workforce in India, Describe the demand for labour, The challenges to industrial relations, Labour laws pertaining to Industrial relations viz Trade Union act, Industrial dispute act, Factories act, A paradigm shift from Industrial relations to Employee relations, Understand the Employee relations management. Describe the differences in perspective of employee relations and industrial relations.
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Odd
3	**Type of course**	Elective
4	**Code of the subject**	MS031

5	**Title of the subject**	Corporate Restructuring
6	**Any prerequisite**	Financial Reporting and Control Financial Engineering and Management
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	The objective of this course is to sensitize the students about the need for corporate restructuring for achieving fast growth and maximize shareholders' value in the context of ever-increasing competition thrown up by liberalization and globalization of Indian economy. The focus of this course, however, will be to analyse the decisions in a financial perspective emphasizing valuation.
9	**Brief Contents**	Opening of the economy, Global view, Indian scenario, Economic liberalization, Corporate restructuring- mergers, acquisitions, and demergers, Mergers and amalgamations, Search for a merger partner, Negotiations, steps, and formalities, Demergers-divestitures, Spin off, Equity carved out, Split off, Split up, Reconstruction, Modes of demerger, Tax aspects, Advantages, and procedure of reverse merger- Requirements, Takeover by reverse bid, Techniques of and procedure for organizing takeover bids, Search for acquisition of target company, Procedure for takeovers and acquisitions, Valuation and exchange ratio-valuation of listed and unlisted companies, Modes of valuation, Fixing price for acquisition, Determination of share exchange ratio on merger, Feasibility analysis for cash acquisition, Valuation practices in India, Funding of merges and acquisitions-financing alternatives, Management buyouts, Leveraged buyouts, Post-merger management- accomplishment of objectives, Performance after merger, Mergers and accusations overseas by Indian corporates
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Even
3	**Type of course**	Elective
4	**Code of the subject**	MS032
5	**Title of the subject**	Corporate Tax Planning
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	After the completion of this course, students will be able to understand and apply corporate tax provisions to real life business problems efficiently using appropriate concepts of taxation laws for corporate tax planning.
9	**Brief Contents**	Concept of tax planning, Tax management, Tax evasion, Tax avoidance, Corporate tax in India, Types of companies,

		Residential status of companies and tax incidences, Tax liability and minimum alternative tax, Tax on distributed profits of companies, Tax planning with reference to setting up a new business, locational aspect, Nature of business, Form of business, Tax planning with reference to financial management decision-capital structure, Dividend including deemed dividend and bonus shares, Tax planning with reference to specific management decisions - Make or buy, Own or lease, Repair or replace, Tax planning with reference to employee remuneration, Tax Planning with reference to business restructuring- Amalgamation, Demerger, Slump sale, Transfer between holding and subsidiary companies, Tax deducted at source, Advance Tax, Double taxation relief, Goods and service tax planning, Transfer pricing and taxation.
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Odd
3	**Type of course**	Elective
4	**Code of the subject**	MS033
5	**Title of the subject**	Economic and Financial Modeling
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	The students will be able to: Learn the skills for framing finance and economy modeling. Develop problem solving abilities in the context of both macroeconomics and microeconomics. Analyze the company / industry performance on relevant financial parameters using historical information on companies
9	**Brief Contents**	Economic Modelling: Classical model of national income; distribution of national in come to the households; fiscal policy and the allocation of resources between consumption, investment and government purchases; modelling economic growth, Modelling inflation; net exports; capital flows and exchange rates in the long run; Mundell Fleming model of business cycle; Edgeworth-Bowley box and the production possibility curve, Financial Modelling: Introduction to financial modeling; basic excel for financial modeling (formatting of excel sheets; use of formula functions; data filter and sort; charts and graphs; table formula and scenario building; vlookup; pivot tables), Introduction to financial statement analysis; financial reporting mechanics; income statement; balance sheet; cash flow statement; financial analysis techniques; inventories; long lived assets; non-current liabilities; financial statement

		application, Financial ratio analysis for financial statement interpretation; time value of money; long term financing; cash flow waterfall & resolve circular reference problem in interest during construction.
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Even
3	**Type of course**	Elective
4	**Code of the subject**	MS034
5	**Title of the subject**	Entrepreneurial Finance
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Students will be able to Understand the importance of financial management and managing a new venture. Learn analyzing the various sources of investment and also know the support provided by the state and central government for entrepreneurship. Determine the various financial supp ort schemes provided different institutions to the entrepreneurs.
9	**Brief Contents**	Financing and managing new venture: Importance of financial management as an integral part of entrepreneurship; conducting a feasibility analysis; what lenders and investors look for in a business plan, Sources of Finance: Various sources of investment; basics of venture capital and angel investment; start-up culture; various measures of encouragement and support being provided by the state and central government for strengthening the entrepreneurial culture, Institutional Financial Support: Schemes and functions of rate of Industries; District Industries Centres (DICs); Industrial development corporation (IDC); State financial corporation (SFCs); Small scale industries development corporations (SSIDCs); Khadi and village industries commission (KVIC); Technical consultancy organisation (TCO); Small industries service institute (SISI); National small industries corporation (NSIC); Small industries development bank of India (SIDBI). Evaluating new venture: Project evaluation; Real options and risk assessment, Financial assessment of new venture: Measuring and evaluating financial performance; financial strategy and capital structure
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Odd
3	**Type of course**	Elective

4	**Code of the subject**	MS035
5	**Title of the subject**	Management of Financial Services
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Students will be able to Enable participants, understand the financial services industry, regulatory environment, financial analysis, and risk management. Learn investment management, banking operations, financial planning, and financial technology, and ethics and professionalism. Determine the financial markets, financial intermediation and different financial services.
9	**Brief Contents**	Introduction to Financial Services: Financial services; Financial services sector in India: overview of financial services in India; nature scope and types of financial services: fund based and non-fund based financial services; venture capital: concept and types; regulatory framework; private equity; strategic secrets of private equity, investment strategies, hedge funds; new venture financing; risk & return in venture capital, Mutual Funds and Pensions Funds: Mutual funds and pensions funds; insurance services; bank assurances; reinsurances; securitization; Indian banking and financial crisis; asset reconstruction companies; depositaries; credit cards; micro/macro finance; financial inclusion, Plastic Money - Concept and different forms of plastic money - credit and debit cards, pros and cons. Credit process followed by credit card organizations. Factors affecting utilization of plastic money in India, Financial Depository: Depository – introduction, concept, depository participants; functioning of depository systems; process of switching over to depository systems; benefits; depository system in India; dematerialization and rematerialization role; objectives and functions of SEBI and its guidelines relating to depository system, Credit Rating & Merchant Banking: Credit Rating: the concept and objective of credit rating, various credit rating agencies in India, credit rating agencies – importance, issue, difference in credit rating, rating methodology and benchmarks, are Indian credit rating credible? International credit rating agencies – crisis of confidence?, Merchant Banking: origin and development of merchant banking in India scope, organizational aspects and importance of merchant bankers. latest guidelines of SEBI w.r.t. merchant bankers. Debt Securitization & Risk Management in Banks: Debt Securitization: meaning, features, scope and process of securitization. factoring: development of factoring types & importance, procedural aspects in factoring, financial aspects, prospects of factoring in India, Risk Management in Banks: credit risk management, operational risk management,

		market risk management, corporate treasury management, liquidity risk management, governance risk and compliance.
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Even
3	**Type of course**	Elective
4	**Code of the subject**	MS036
5	**Title of the subject**	Financial Risk Management
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Understand the concept of financial risk and a comprehensive understanding of the various types of financial risks that organizations face. Developing the skills to identify and measure financial risk using various quantitative and qualitative techniques. Understanding to develop and implement the strategies to manage financial risk. Understanding the regulatory environment surrounding financial risk.
9	**Brief Contents**	Overview of financial risks, Risk, expectations, and asset prices, Volatility behavior and forecasting, Market risk measurement, Value-at-Risk and its implementation, Credit and counterparty risk, Leverage and leverage risk, Liquidity risk, Extreme events and market risk measurement, Assessing the accuracy of Value-at-Risk, Incorporating extreme events into risk measurement, Credit risk measurement, Portfolio credit risk measurement, Structured credit risk, Financial crises, Overview of regulatory policy, Regulatory capital and liquidity standards, Financial stability regulation
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Odd
3	**Type of course**	Elective
4	**Code of the subject**	MS037
5	**Title of the subject**	Personal Wealth Management
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	After completion of the course, students will be able to understand personal financial planning as an approach for investment, insurance, taxation, and retirement and can identified the best combination of different financial products in view of different time horizons and propositions of risk return trade-off.
9	**Brief Contents**	Introduction and importance of personal wealth management, Concept of personal financial planning, Objective of personal

		financial planning, Steps involve in personal financial planning process, Emergence of personal financial planning in India, Financial institutions and products, Concept of risk, Types of risk, Measuring risk, Understanding return, Concept of compounding, Real and nominal rate of return, Tax adjusted return, Risk adjusted returns, Asset classes, Portfolio construction, Practical asset allocation and rebalancing strategies, Portfolio monitoring and re-balancing, Need for insurance, Requirement of an insurable risk, Role of insurance in personal finance, Steps involve in insurance planning, Insurance products, Products and functions of life and non-life insurance business, Need of life insurance, Retirement planning process, Estimation of retirement corpus, Determination of retirement corpus, Retirement products, Understand income tax principles, Tax aspects of investment products, Personal tax planning, Estate planning.
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Even
3	**Type of course**	Elective
4	**Code of the subject**	MS038
5	**Title of the subject**	International Finance
6	**Any prerequisite**	Financial Engineering and Management
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Students will be able to understand the significance of financial management in the global context particularly for MNCs, importance of foreign exchange market and international financial institutions, and applications of financial instruments of the international financial markets for the working capital and financing decisions.
9	**Brief Contents**	Concept and comparison of international trade, International business, International finance, International trade theories, Balance of payments and capital account convertibility, Development of international monetary system, Nominal, real and effective exchange rates, Determination of exchange rates, Factors influencing exchange rates, Theories of exchange rate behaviour; International financial institutions, Major participants in foreign exchange market, Spot market and forward market, Markets for currency futures and options, Foreign exchange rates, Techniques of exchange rate forecasting, Nature and Measurement of Foreign Exchange Exposure, Management of Foreign Exchange Exposure, Theories of Foreign direct investment, International capital budgeting- Evaluation criteria,

		Computation of cash flows, Cost of capital, Adjusted present value approach, Evaluation and management of political risk, International Portfolio Investment-concept of optimal portfolio, modes of international portfolio investment, An overview of international financial markets, Channels for international flow of funds, Multilateral development banks, International banking, International financial instruments, Financial swaps, Management of interest rate risk, Working capital policy, Management of current assets, Financing current assets, Foreign trade documentation, Modes of payments in international trade, Methods of trade financing.
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Odd
3	**Type of course**	Elective
4	**Code of the subject**	MS039
5	**Title of the subject**	Project Appraisal and Finance
6	**Any prerequisite**	Elementary Financial Management
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	The course aims at providing an understanding of project identification, feasibility study of the project and project report preparations. It facilitates the knowledge about different sources of financing and financial appraisal technique. It provides an acquaintance about social cost benefit analysis with understanding for different types of project risk and also post assessment of the project.
9	**Brief Contents**	An introduction to project appraisal, Project appraisal and evaluation , Project life cycle, Project cycle management , Cost benefit analysis of Private and public sector projects; Identification of investment opportunities – industry analysis review of project profiles, – feasibility study , Project identification and formulation , Generation of project ideas, Basic principles of project analysis entrepreneurship concept, Theory and perspective, Market feasibility analysis of a project, Need for market analysis, Demand and supply analysis, Collection analysis, primary /secondary data, Forecasting of market growth; Market forecasting techniques, Technical appraisal of a project, Technology tie ups and diffusion; Management of technology and business, Financial feasibility analysis: Estimation of cost of project & means of financing, Arrangement of funds, Traditional sources of financing: Equity shares, preference shares, Debentures / bonds, loan from financial institutions, Alternative sources of financing: FDI & FII, private equity, securitization, venture capital, Different business/project

		support government schemes, Government funding for projects, Startup schemes of government, Projected cash flows of project, Appraisal criteria, NPV,IRR, PI, PBP, ARR, Economic analysis of a project : Social cost benefit analysis – rationale of SCBA, direct and indirect cost and benefits, shadow price efficiency and equity in project appraisal, UNIDO approach, Little Mirrlees approach, Environment impact assessment of a project and social impact assessment of a project, Risk and sensitivity Analysis, taxonomy of risks, break even analysis, Sensitivity analysis, Risk analysis using simulation models and decision trees, Monitoring and evaluation of a project – PERT / CPM, Monitoring mechanism, valuation and lessons, project audit, Preparation of project report, Case analysis.
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Even
3	**Type of course**	Elective
4	**Code of the subject**	MS040
5	**Title of the subject**	Security Analysis and Portfolio Management
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	The objective of this course is to help students gain an understanding of the evolving domestic and international investment landscape in general, and the Indian capital market with special emphasis on the availability of different financial products and stock exchange operations. It aims to provide a thorough understanding of portfolio management theory and practice. With the goal of assisting the participants in making wise investment choices in the context of portfolio investment, significant theories, techniques, laws, and advancements in investment theory will be covered.
9	**Brief Contents**	Investment Alternatives and Objectives, Organization and Mechanics of Securities Markets, Types of Security Markets and their Functions, Stock Exchanges, Depository, Stock Indices, Role of Regulatory Authorities, and various participants in markets, Market Microstructure, Risk and Return dynamics, Utility Theory, Portfolio Theory, CAPM Capital Asset Pricing Model (CAPM), Arbitrage Pricing Model (APT), Multi-factor Models, Sharpe's Single Index Model, Lagrange Multiplier Theory, Basics of futures and options, Fundamental Analysis: Macroeconomic activities and security markets, The Cyclical indicator approach, Monetary variables, Business cycles and industry sectors, Evaluating Industry life cycle, Analysis of industry competition and industry rate of returns, Company analysis, Analysis of Financial statement and

		Stock valuation, Technical analysis: Assumption, Advantages, Challenges, Types of Charts, Technical Trading Rules, and Indicators, Introduction to Efficient Market Hypothesis, Random Walk Model, Forms of EMH, Empirical Evidence, Bond Fundaments, Valuation and Bond Yield, Term structure, Bond Theorems, Bond Portfolio Management Strategies, Passive and Active Management, Portfolio Management, Portfolio Objectives, Evaluation of Portfolio Performances, Application of Portfolio performance measures
10	**Contents for lab**	No

1	**Program**	MBA/IPG MBA
2	**Semester**	Odd
3	**Type of course**	Elective
4	**Code of the subject**	MS041
5	**Title of the subject**	Consumer Behavior
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Explaining the basic concepts of Consumer Behavior and its linkages to marketing. Examine how markets are segmented, and brands are positioned. Analyse the phenomenon of consumer learning about a brand and forming perceptions about it. Compare how the theoretical aspects of Consumer Behaviour are practiced in real scenarios by marketers and brands.
9	**Brief Contents**	Consumers, Marketers, and Technology, Consumer Behavior and Technology, Market Segmentation and Real-Time Bidding, The Consumer as an Individual, Consumer Motivation and Personality, Consumer Perception and Positioning, Consumer Learning, Consumer Attitude Formation and Change, Communication and Consumer Behavior, Persuading Consumers, From Print and Broadcast to Social Media and Mobile Advertising, Reference Groups and Communities, Opinion Leaders, and Word-of-Mouth, Social and Cultural Settings, The Family and Its Social Standing, Cultural Values and Consumer Behavior, Cross-Cultural Consumer Behavior: An International Perspective, Consumer Decision-Making, Marketing Ethics, and Consumer Research, Consumer Decision-Making and Diffusion of Innovations, Marketers' Ethics and Social Responsibility, Consumer Research.
10	**Contents for lab**	Case study exercises

1	**Programme**	MBA/IMG
2	**Semester**	Even
3	**Type of course**	Elective
4	**Code of the subject**	MS042
5	**Title of the subject**	Advertisement and Sales Promotion Management

6	**Any prerequisite**	Marketing Management
7	**L-T-P**	3-0-1
8	**Learning Objectives of the subject**	To understand the key concepts of advertising and sales promotion. To explore an organisation's numerous copy and media decisions. To understand the link between advertising and sales promotion for enhancing brand equity
9	**Brief Contents**	Role of integrated marketing communication, Role of IMC in marketing process, Marketing and promotions process, Organizing for advertising and promotion: the role of Ad agencies and other marketing communication organizations, Perspectives on consumer behavior, The communication process, Source, message and channel factors, Establishing objectives and budgeting for the promotional program, Creative strategy: planning and development, Media planning and strategy, Media decisions, Evaluation of broadcast media, The internet and interactive media, International advertising and promotion, Advertisement effectiveness, Sales promotion, Linkage between advertising and sales promotion, Brand equity, Regulation of advertising and promotion, Evaluating the social, ethical, & economic aspects of advertising & promotion.
10	**Contents for lab**	Case study exercises Class projects and exercises Field projects and company visits

1	**Programme**	MBA/IMG
2	**Semester**	Odd
3	**Type of course**	Elective
4	**Code of the subject**	MS043
5	**Title of the subject**	Product and Brand Management
6	**Any prerequisite**	Marketing Management
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	After completion of this course students will be able to understand the concept of product and brand management, branding as marketing strategy; brand equity and its measurement, and operational aspects of brand management.
9	**Brief Contents**	Introduction and concept of product management, Management of new product development process, Understanding and managing product life cycle, Introduction to brand management, Brand management process, Brand choice decisions and models, Brand identity, Brand communication, Brand positioning, Brand image and personality, Brand valuation, Brand tracking and monitoring, Building brands in Indian market, Launching a new brand, Revitalizing brands, Brand extension strategies, Brand portfolio management, Managing brands across geographical borders, Managing brand experience, Digital branding, Employment branding, Co-branding.
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Even
3	**Type of course**	Elective
4	**Code of the subject**	MS044
5	**Title of the subject**	E-Marketing
6	**Any prerequisite**	Marketing Management
7	**L-T-P**	3-0-1
8	**Learning Objectives of the subject**	To explore frameworks for the successful planning and execution of e-campaign strategies. To understand ROI enhancement, customer lifetime value and firm profitability aligned with business goals through e-marketing. To plan and implement search engine and social media campaigns in simulated environments. To understand leveraging digital marketing funnel for better customer engagement. To understand reach, engagement and conversions with paid and unpaid e-campaigns. To measure and optimize the e-campaigns through different matrices. Strategic application of digital marketing best practice.
9	**Brief Contents**	Marketing in the digital world, Exploring customer behaviour and customer journey in digital world, Crafting and executing digital strategy, Aligning business strategy, Reaching and engaging the customer, Strategies for paid and unpaid e-campaigns, Display, social media and e-mail campaigns, User experience and transformation, True personalization, Customer service, Content strategy, Matrices for strategy evaluation, Digital analytics, Emerging technologies
10	**Contents for lab**	Case study exercises Class projects and exercises Field projects and company visits

1	**Programme**	MBA/IMG
2	**Semester**	Odd
3	**Type of course**	Elective
4	**Code of the subject**	MS045
5	**Title of the subject**	Retail Management
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Upon successful completion of the course, students should be able to: Demonstrate an understanding of how retailers develop a retail mix to build a sustainable competitive advantage. Explain how retailers use marketing communications to build a brand image and customer loyalty. Understand the integration of merchandise management and supply chain strategies leading to excellent customer service. Understand the financial implication of strategic retail decisions. Demonstrate an understanding of decisions retailers make to satisfy customer needs in a rapidly changing and competitive environment.

9	**Brief Contents**	Introduction to the world of Retailing : A. History of retail, B. Retail overview and present scenario C. Concept and Functions performed by retailers D. Emerging Trends and career opportunities in retailing, Types of Retailers: A. Retailer characteristics B. Retail Formats - Store based, Non-store based, Web based C. Various format within store based retailing e.g. specialty store, hyper market, supermarket, buying decision process : A. The buying process - need recognition, information search, evaluation of alternatives. B. Social factors influencing the buying process family, reference groups and culture retail market strategy: A. Definition of retail and market strategy B. Target market C. Building a sustainable competitive advantage like - customer's loyalty, location, human resource management, distribution and information system, vendor relations. D. Growth strategies - Market penetration, market expansion, retail format development diversification, integration, E. Global retail strategies F. Strategic retail planning process, Choosing retail location: A. Types of locations - Unplanned locations free standing sites B. Evaluation of area for location C. Evaluating specific area for locations, HRM In Retailing: A. Human resource planning, Recruitment and selection, training and development of retail employees. B. Motivation of retail employees, C. team building in retailing D. Employee Rewards and Incentives, Store Planning: Design & Layout, Retail Image Mix, effective retail space management, floor space management, Retail Supply Chain Management: A. Introduction to supply chain management B. The distribution across centres 24 C. Collaboration between retailer and vendor in SCM D. Inventory Management E. Warehousing F. Transportation G. Use of IT in SCM 8. Customer Relationship Management - The CRM process 9. Retail Information System InstructrualStrate, Merchandise Pricing: Concept of Merchandise Pricing, Pricing Objectives, External factors affecting a retail price strategy, Pricing Strategies, Types of Pricing.
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Even
3	**Type of course**	Elective
4	**Code of the subject**	MS046
5	**Title of the subject**	International Marketing
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	The course aims at providing knowledge to students to the global business activities, marketing in international business and global forces transforming the international business today. Participants will learn to plan effectively for the marketing of consumer and business needs and wants on an international level. Special emphasis will be placed on cultural and environmental aspects of international trade, and integration of culture and marketing functions.

9	**Brief Contents**	An Overview of International Marketing: The Scope and Challenge of International Marketing, The Dynamic Environment of International Trade, The Cultural Environment of Global Markets: History and Geography: The Foundations of Culture, Cultural dynamics in assessing Global markets, Culture, Management style, and Business systems, The Political environment: A Critical concern, The International legal environment: Playing by the rules , Assessing Global Market Opportunities: Developing a Global Vision through Marketing Research, Economic Development and the Americas, Europe, Africa, and the Middle East, The Asia Pacific Region, Developing Global Marketing Strategies: Global marketing management: Planning and Organization, Products and services for consumers, Products and services for businesses, International marketing channels, Integrated marketing communications and International advertising, Personal selling and Sales management, Pricing for international markets, Implementing Global Marketing Strategies: Inventive Negotiations with International Customers, Partners, and Regulators
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Odd
3	**Type of course**	Elective
4	**Code of the subject**	MS047
5	**Title of the subject**	Sales and Distribution
6	**Any prerequisite**	Marketing Management
7	**L-T-P**	3-0-1
8	**Learning Objectives of the subject**	To understand the key concepts of sales and distribution. To explore an organisation's numerous distribution and sales channels. To broadly look at the role of sales and distribution as a key element within marketing strategy. To equip with basic skills required in sales and distribution management.
9	**Brief Contents**	Sales management and the business enterprise, Sales management, personal selling, and salesmanship, Setting personal-selling objectives, Determining sales-related marketing policies, Formulating personal- selling strategy, The effective sales executive, The sales organization, Sales department relations, Sales personnel management, Recruitment and selection, Sales training, motivation and compensation, Evaluation and supervision, Sales budget, Territories, control and cost analysis, Marketing channels, Managing channel partners, Channel information system, Logistics and supply chain management, International sales and channel management
10	**Contents for lab**	Case study exercises Class projects and exercises Field projects and company visits

1	**Programme**	MBA/IMG
2	**Semester**	Even
3	**Type of course**	Elective
4	**Code of the subject**	MS048
5	**Title of the subject**	Marketing Research
6	**Any prerequisite**	Basic knowledge of statistics and research methodology
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	To understand the formulation of marketing problem into a feasible research question. To design and execute a basic survey research project. To understand the research tools and techniques for executing a marketing project and decision making.
9	**Brief Contents**	Introduction to Marketing Research: Marketing research an introduction, marketing research process design, Research design formulation: Measurement and scaling, questionnaire designing, sampling and sampling distributions, Sources and collection of data: Secondary data sources, Data collection: survey and observation, experimentation, fieldwork and data preparation, Descriptive statistics and data analysis: Measures of central tendency, measures of dispersion, hypothesis testing for single population and two populations, ANOVA and Experimental designs, hypothesis testing for categorical data (chi-square test), correlation and simple linear regression analysis, Multivariate analyses (multiple regression analysis, discriminant analysis, conjoint analysis, factor analysis, cluster analysis, multidimensional scaling and correspondence analysis, Result presentation: Presentation of results, report writing, Applications of marketing research: Marketing mix research: Product, price, place and promotion research
10	**Contents for lab**	Descriptive statistics and data analysis: Measures of central tendency, measures of dispersion, hypothesis testing for single population and two populations, ANOVA and Experimental designs, hypothesis testing for categorical data (chi-square test), Correlation and simple linear regression analysis, Multivariate analyses (multiple regression analysis, Discriminant analysis, conjoint analysis, factor analysis, Cluster analysis, Multidimensional scaling and correspondence analysis

1	**Programme**	MBA/IMG
2	**Semester**	Odd
3	**Type of course**	Elective
4	**Code of the subject**	MS049
5	**Title of the subject**	Service Marketing
6	**Any prerequisite**	Basic knowledge of Marketing Management
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	To provide an in-depth appreciation and understanding of the unique challenges inherent in managing and delivering quality services. To develop an understanding of the 'state of the art'of service

		management thinking. To understand the marketing concepts in the perspectives of services.
9	**Brief Contents**	Service Marketing Introduction : Meaning and nature of services, classifications of services, Introduction to service marketing, Evolution of service marketing, Service marketing mix and Gaps model: 7Ps of service marketing, service gaps framework, perceived service quality, model of service marketing, Service design and service delivery: Introduction to service design and service delivery, service delivery process, service encounters and moments of truth, employee role in service delivery, role of service provider, intermediaries involved in service process and delivery, managing demand and supply of service, STP strategy for Services: Need for segmentation of services, bases of service segmentation, segmentation strategies in service marketing, need for targeting and positioning strategies for services, Consumer behaviour in service marketing: Customer expectations in services, Service costs experienced by consumer, the role of consumer in service delivery, customer responses in services, customer delight, service failure and recovery, Emerging issues in Service marketing: Strategic approach in service marketing, Service marketing in e-commerce and e-marketing, Telemarketing services
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Even
3	**Type of course**	Elective
4	**Code of the subject**	MS050
5	**Title of the subject**	Strategic Marketing
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	On completion of this course, the student will be able to: Understand and critically discuss the marketing activities that impinge on our daily lives as business managers and citizens. Critically evaluate key marketing theory, concepts, research and current practice. Discuss critically decision-making processes and frameworks for selecting marketing objectives, target markets and marketing mixes. Discuss critically how marketing practice is influenced by contemporary challenges in the operating environment. Apply theoretical frameworks to real-world marketing innovation challenges: identifying their key features and implications, setting appropriate marketing objectives and evaluating alternative marketing strategies.
9	**Brief Contents**	Fundamentals of Marketing Strategies, Marketing management for a turbulent era, The marketing fit with corporate and business strategies, Capturing key Marketing environmental insights, Customer insights and customer connections , Capturing marketing insights for demand measurement, Market segmentation and target marketing, Conducting Marketing audits, Branding and positioning, Marketing strategies for competitive and market scenarios, The integrated marketing mix, Marketing Metrics and Analytics,

		Organising, planning, delivering and measuring market performance, Innovation and Marketing Strategy, Marketing Channels and Pricing, Marketing Communications, Digital and Social media marketing, Marketing strategy to the bottom of the pyramid, Frugal & Grass root marketing
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Odd
3	**Type of course**	Elective
4	**Code of the subject**	MS051
5	**Title of the subject**	Public Policy and Processes
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Upon successful completion of the course, student should be able to: Describe formulation and implementation of policies. Employ role of various institutions and interest groups in policy formulation and implementation process. Assess role of various stakeholders in influencing policy processes and associated outcomes.
9	**Brief Contents**	Concepts and Theories of Public Policy and Processes: Understanding public policy, Policy types, Approaches to policy making- various models of policy making and their relevance, Institutions and its role in Public Policy: Policy making institutions in India: Judiciary, executive and legislature, How policy making is accomplished in India, Constitutional/statutory bodies and its role in policy process, Political institutions, Changing role of institutions: new public management, New governance model, Role of networks in shaping public policy, Policy Process: Formulation of policies: Principal phases of policy process: issue identification/agenda setting, Stakeholder consultation and review, Transparency in policy formulation, Identifying the main actors/stakeholders in the policy process, Idea of political power and influence, Regional versus national interest, Policy Process: implementation of policies: policy implementation, Identifying implementation gaps, Feedback on policies, Policy implementation as a political process: political economy, Service Delivery, Accountability and people's participation: role of decentralization and local governance, Policy Change: Identifying role of domestic and international actors in determining policy choices, Endowments and Constraints on their power to determine policy choices civil Society/pressure groups/networks and its role in influencing policy decisions, Market (private sector/business) as an agent in influencing policy decisions, Media and its role in public policy

10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Even
3	**Type of course**	Elective
4	**Code of the subject**	MS052
5	**Title of the subject**	Public Private Partnerships
6	**Any prerequisite**	
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Upon successful completion of the course, student should be able to: Understand the role of cooperation between public and private sectors in delivering public services; to develop understanding of PPP models and their contextual suitability; and employ various types of partnerships and assess their consequences.
9	**Brief Contents**	PPP Concept, Benefits and Limitations-Public service delivery and roles of government, recent trend of reforms on public service delivery, basic theories of pubic private partnership (PPP) PPPs Models-Concept and practices of outsourcing, Competition between private and public sectors, such as competitive sourcing and market testing, concept and practices of various types of private finance initiative (PFI), recent issues in PFI practices, theories and practices of deregulation, involvement of citizens, non-profit organization (NPOs) and social enterprises in public service delivery, Basic theories and practices of executive agencies and public corporations, theories and practices of privatization, recent practices to bring outsourced public services back in-house Government Role for Creating an Enabling PPP Environment-Conventional and innovative approaches for improving government procurement, practical models of shared services in public sector, advantages and disadvantages of PPP, strategies, steps, monitoring, evaluation of PPP, skills and resources required for managing PPP Risk Identification and Allocation-Risk assessment, value for money (VfM) and commercial feasibility exercises, risk identification, political risks, market risks, challenges for public service delivery and possible (desirable) future directions PPP Structure and Financing- Financing options, profitability assessment, funding cost, project attractiveness.
10	**Contents for lab**	N/A

1	**Programme**	MBA/IMG
2	**Semester**	Odd
3	**Type of course**	Elective
4	**Code of the subject**	MS053
5	**Title of the subject**	Sustainable Development
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	To enhance students understanding of the SDGs to create a better-informed citizenry, which will lead to a more sustainable action by

		all and for all. To understand the basic concept of Sustainable Development (SD), the environmental, social and economic dimensions. To know the history of the SD idea. To Be able to discuss the conflicts which are involved in the SD concept on the national as well as on the global scale. To be familiar with potential strategic options for SD (efficiency, sufficiency). To be able to discuss the (dis-advantages) of instruments for SD. To understand the SD challenge for companies, their responsibility and their potentials for action.
9	**Brief Contents**	Sustainability, sustainable development, and the sustainable development goals; SDGs overview, goals, and targets, Instruments for sustainable development, SDG Goal part-1 : Poverty, Hunger, Good health and Well-being, SDG Goal part-2 : Gender equality, Reduced inequalities, SDG Goal part-3 : Clean water and sanitation, Affordable and clean energy, SDG Goal part-4: Quality education, Decent work and Economic growth, SDG Goal part-5 Industry, Innovation, and Infrastructure; SDG goal part- 6: Sustainable cities and communities, Responsible Consumption and Production, SDG Goal part-7 Climate action, Life below water, Life on land; SDG Goal part-8 Peace, Justice, and Strong institutions, #17 Partnerships for goals, Implementing the SDGs, Monitoring, Evaluation, Reporting, Beyond sustainability to radical transformation, Company perspectives
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Even
3	**Type of course**	Elective
4	**Code of the subject**	MS054
5	**Title of the subject**	Management of Rural and Social Sector
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Course is designed to inculcate students with realistic understanding of rural segment and society for the application of managerial and technological learning.
9	**Brief Contents**	Indian rural and social sectors, Rural and sector economic development, Different rural and social sector reform programmes of Asia; Local, National and International focuses and policies for economic reforms of rural and social sectors.
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Odd
3	**Type of course**	Elective
4	**Code of the subject**	MS055

5	**Title of the subject**	Information Technology Enabled Services
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Understand the business strategy and business implications for strategic IT planning. Equip students to understanding the concepts of IT infrastructure library and services
9	**Brief Contents**	Business Strategy: Challenges- opportunities, Interconnection establish principles before practice, IT strategy, Application strategy, Technology strategy for IT, IT management strategy, Developing IT strategy for competitive advantage, Stages of IT strategy development and implementation, Challenges of IT and business strategy alignment, Inhibitors of business and IT strategy alignment, Three-D framework for Business and IT strategy alignment, Business implications for IT strategy and planning, Strategic IT planning, Motivations, SITP Process: Prevalent planning approaches difficulties, Best practices for achieving good SITP, SITP approaches: Prevalent researches, Defining EITA, Contents of a typical enterprise IT architecture, Standard for enterprise IT architecture, Technology Management strategy framework, Information Technology Infrastructure Library (ITIL), ITIL overview- ITIL Service- support processes, Incident management, Problem management, Service delivery, Service level management- Financial management, Capacity management, IT Service continuity management (ITSCM), Availability management, Imperatives for outsourcing, IT management layers- Variants of outsourcing, Business process outsourcing, Insourcing.
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Even
3	**Type of course**	Elective
4	**Code of the subject**	MS056
5	**Title of the subject**	Management of Non-Formal Organization
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	The Non-Informal sector is the backbone of the Indian Economy. The understanding of the issues related to the informal sector is necessary to have a better understanding of the Indian economy. This course would try to educate the researcher on different issues related to the informal sector in India and across the developing countries. This paper would enable the management student and potential researcher to conduct some in-depth research work in the unorganized sector.
9	**Brief Contents**	Introduction: Why the Informal Economy Matters to Management, Concept, Features and Types of Non formal sector, Difference between formal and informal organisation, Function of Non formal

		sector ,Formalizing informal sector, Challenges of the informal economy for the field of Management, Theoretical Foundations: A General Equilibrium approach, Communication, Visibility, and the Informal Economy, Technology in Non formal sector – Application and challenges, Management of The ICT in Non informal sector, Small Business in the informal Economy, Informal Financial Services: A Proposed Research Agenda, The hidden enterprise culture: Entrepreneurship in the Non informal sector, Organization and Contract in the Informal Economy, Comparative Economic Organization Revisited: Hybrid Governance in the Informal Economy, Factors Influencing the Registration Decision in the Informal Economy, Informal Firms in India What Do We Know and Where Does the Research Go, Healthcare in the Informal economy, Subsistence Entrepreneurs and Formal Institutions: Semi-formal Governance among Indian Entrepreneurs, Learning From India's Aadhaar Project, Lesson form Akshyapatra',Lesson from 'Arvind Eye care'
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Odd
3	**Type of course**	Elective
4	**Code of the subject**	MS057
5	**Title of the subject**	Healthcare System Management
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Upon successful completion of the course, student should be able to: Delve into the components and functions of health care provider organizations and assess the unique challenges involved in managing complex health care organizations. Appraise the motivations and interests of key internal and external stakeholders and managing expectations and communicating with these stakeholders. Weigh common problems and decisions faced by health care managers, and explore the implications of various alternative strategic solutions
9	**Brief Contents**	Issues in health management: leadership, management and motivation, Organizational behavior and management thinking, Strategic planning, Information systems, Complexity and purpose of health care organizations, For profit and non-profit organizations, Management responsibilities and health care operations, Management code of ethics and ethical decision-making, Care and cure processes, Operations management, Impact of the pandemic on providers and caregivers, Physician practice management, The post-pandemic health care system, Strategic planning, Industry consolidation
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Even
3	**Type of course**	Elective
4	**Code of the subject**	MS058
5	**Title of the subject**	Emerging Areas in Management of Social Sector
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Upon successful completion of the course, student should be able to: Apply social work skills, values and ethical responsibilities to leadership, management and supervision practices. Describe and critique selected theories, research and practice approaches relevant to effective and socially just leadership and management in human service organizations. Create a plan for strategic change using concepts, processes and skills related to leadership, management, and organization development.
9	**Brief Contents**	Corporate governance, Project management, Social entrepreneurship for sustainable development, Strategic planning for social sector organizations, Essentials of managing a social organization, Understanding financial statements, Measuring project results, Systems and tools for impact measurement, Social impact marketing and sales management, Scaling a social enterprise, Attracting & raising capital, Market regulation and compliance.
10	**Contents for lab**	No

1	**Programme**	MBA/IMG
2	**Semester**	Even
3	**Type of course**	Elective
4	**Code of the subject**	MS059
5	**Title of the subject**	Infrastructure Management
6	**Any prerequisite**	No
7	**L-T-P**	3-0-0
8	**Learning Objectives of the subject**	Understanding the importance of infrastructure in supporting economic development, quality of life, and public safety. Understanding the roles and responsibilities of different stakeholders involved in infrastructure management, including government agencies, private sector organizations, and community groups. Developing skills in infrastructure asset management, including maintenance, repair, and replacement of infrastructure assets. Understanding the principles of sustainable infrastructure development and management, including considerations of environmental and social impact. Developing an understanding of risk management, including identifying, assessing, and mitigating risks associated with infrastructure systems. Understanding the legal and regulatory frameworks governing infrastructure

		development and management. Developing an understanding of the financing and funding mechanisms for infrastructure projects, including public-private partnerships and other innovative financing approaches.
9	**Brief Contents**	Introduction to Infrastructure Management: Definition and scope of infrastructure, Importance of infrastructure management, Historical development of infrastructure management, Types of Infrastructure: Transport, Water and wastewater infrastructure, Energy infrastructure management, Telecommunication management, Asset Management: Asset inventory and condition assessment, life cycle costing, risk management, Funding and Financing of Infrastructure: Public sector funding, private sector funding, public -private partnership, Project Management: Project identification and selection, project planning and design, project procurement and contracting, construction management and supervision. Infrastructure Policy and Regulation: Government policy on infrastructure, regulatory framework for infrastructure management, environment regulations and considerations, Emerging trends in Infrastructure management: New technologies for infrastructure management, Sustainability and resilience considerations, Future challenges and opportunities in infrastructure management
10	**Contents for lab**	No