



ANNA UNIVERSITY, CHENNAI
NON- AUTONOMOUS AFFILIATED COLLEGES
REGULATIONS 2021
CHOICE BASED CREDIT SYSTEM

B.TECH. ARTIFICIAL INTELLIGENCE AND DATA SCIENCE

I. PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

Graduates can

1. Utilize their proficiencies in the fundamental knowledge of basic sciences, mathematics, Artificial Intelligence, data science and statistics to build systems that require management and analysis of large volumes of data.
2. Advance their technical skills to pursue pioneering research in the field of AI and Data Science and create disruptive and sustainable solutions for the welfare of ecosystems.
3. Think logically, pursue lifelong learning and collaborate with an ethical attitude in a multidisciplinary team.
4. Design and model AI based solutions to critical problem domains in the real world.
5. Exhibit innovative thoughts and creative ideas for effective contribution towards economy building.

II. PROGRAM OUTCOMES (POs)

PO# Graduate Attribute

- 1 **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
- 2 **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
- 3 **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
- 4 **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
- 5 **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
- 6 **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
- 7 **Environment and sustainability:** Understand the impact of the professional engineering

solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

- 8 **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
- 9 **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
- 10 **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- 11 **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
- 12 **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

III. PROGRAM SPECIFIC OUTCOMES (PSOs)

Graduates should be able to:

1. evolve AI based efficient domain specific processes for effective decision making in several domains such as business and governance domains.
2. arrive at actionable Foresight, Insight, hindsight from data for solving business and engineering problems
3. create, select and apply the theoretical knowledge of AI and Data Analytics along with practical industrial tools and techniques to manage and solve wicked societal problems
4. develop data analytics and data visualization skills, skills pertaining to knowledge acquisition, knowledge representation and knowledge engineering, and hence be capable of coordinating complex projects.
5. able to carry out fundamental research to cater the critical needs of the society through cutting edge technologies of AI.

PROGRESS THROUGH KNOWLEDGE

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CURRICULA FOR SEMESTERS I TO VIII AND SYLLABI FOR SEMESTERS III AND IV
SEMESTER I

S. NO.	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	IP3151	Induction Programme	-	-	-	-	-	0
THEORY								
2.	HS3151	Professional English - I	HSMC	3	0	0	3	3
3.	MA3151	Matrices and Calculus	BSC	3	1	0	4	4
4.	PH3151	Engineering Physics	BSC	3	0	0	3	3
5.	CY3151	Engineering Chemistry	BSC	3	0	0	3	3
6.	GE3151	Problem Solving and Python Programming	ESC	3	0	0	3	3
7.	GE3152	அறிவியல் தமிழ் /Scientific Thoughts in Tamil	HSMC	1	0	0	1	1
PRACTICALS								
8.	GE3171	Problem Solving and Python Programming Laboratory	ESC	0	0	4	4	2
9.	BS3171	Physics and Chemistry Laboratory	BSC	0	0	4	4	2
10.	GE3172	English Laboratory [§]	EEC	0	0	2	2	1
TOTAL				16	1	10	27	22

[§] Skill Based Course

SEMESTER II

S. NO.	COURSE CODE	COURSE TITLE	CATE-GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	HS3251	Professional English - II	HSMC	2	0	0	2	2
2.	MA3251	Statistics and Numerical Methods	BSC	3	1	0	4	4
3.	PH3256	Physics for Information Science	BSC	3	0	0	3	3
4.	BE3251	Basic Electrical and Electronics Engineering	ESC	3	0	0	3	3
5.	GE3251	Engineering Graphics	ESC	2	0	4	6	4
6.	AD3251	Data Structures Design	PCC	3	0	0	3	3
7.	GE3252	தமிழர் மரபு /Heritage of Tamils	HSMC	1	0	0	1	1
8.		NCC Credit Course Level 1 [#]	-	2	0	0	2	2 [#]
PRACTICALS								
9.	GE3271	Engineering Practices Laboratory	ESC	0	0	4	4	2
10.	AD3271	Data Structures Design Laboratory	PCC	0	0	4	4	2
11.	GE3272	Communication Laboratory / Foreign Language [§]	EEC	0	0	4	4	2
TOTAL				17	1	16	34	26

[#] NCC Credit Course level 1 is offered for NCC students only. The grades earned by the students will be recorded in the Mark Sheet, however the same shall not be considered for the computation of CGPA.

[§] Skill Based Course

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SEMESTER III

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA3354	Discrete Mathematics	BSC	3	1	0	4	4
2.	CS3351	Digital Principles and Computer Organization	PCC	3	0	2	5	4
3.	AD3391	Database Design and Management	PCC	3	0	0	3	3
4.	AD3351	Design and Analysis of Algorithms	PCC	3	0	2	5	4
5.	AD3301	Data Exploration and Visualization	PCC	3	0	2	5	4
6.	AL3391	Artificial Intelligence	PCC	3	0	0	3	3
PRACTICALS								
7.	AD3381	Database Design and Management Laboratory	PCC	0	0	3	3	1.5
8.	AD3311	Artificial Intelligence Laboratory	PCC	0	0	3	3	1.5
9.	GE3361	Professional Development [§]	EEC	0	0	2	2	1
TOTAL				18	1	14	33	26

[§] Skill Based Course

SEMESTER IV

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA3391	Probability and Statistics	BSC	3	1	0	4	4
2.	AL3452	Operating Systems	PCC	3	0	2	5	4
3.	AL3451	Machine Learning	PCC	3	0	0	3	3
4.	AD3491	Fundamentals of Data Science and Analytics	PCC	3	0	0	3	3
5.	CS3591	Computer Networks	PCC	3	0	2	5	4
6.	GE3451	Environmental Sciences and Sustainability	BSC	2	0	0	2	2
7.		NCC Credit Course Level 2 [#]		3	0	0	3	3 [#]
PRACTICALS								
8.	AD3411	Data Science and Analytics Laboratory	PCC	0	0	4	4	2
9.	AL3461	Machine Learning Laboratory	PCC	0	0	4	4	2
TOTAL				17	1	12	30	24

[#]NCC Credit Course level 2 is offered for NCC students only. The grades earned by the students will be recorded in the Mark Sheet, however the same shall not be considered for the computation of CGPA.

SEMESTER V

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	AD3501	Deep Learning	PCC	3	0	0	3	3
2.	CW3551	Data and Information Security	PCC	3	0	0	3	3
3.	CS3551	Distributed Computing	PCC	3	0	0	3	3
4.	CCS334	Big Data Analytics	PCC	2	0	2	4	3
5.		Professional Elective I	PEC	-	-	-	-	3
6.		Professional Elective II	PEC	-	-	-	-	3
7.		Mandatory Course-I ^{&}	MC	3	0	0	3	0
PRACTICALS								
8.	AD3511	Deep Learning Laboratory	PCC	0	0	4	4	2
9.	AD3512	Summer internship	EEC	0	0	0	0	2
TOTAL				-	-	-	-	22

[&] Mandatory Course-I is a Non-credit Course (Student shall select one course from the list given under Mandatory Course-I)

SEMESTER VI

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	CS3691	Embedded Systems and IoT	PCC	3	0	2	5	4
2.		Open Elective – I [*]	OEC	3	0	0	3	3
3.		Professional Elective III	PEC	-	-	-	-	3
4.		Professional Elective IV	PEC	-	-	-	-	3
5.		Professional Elective V	PEC	-	-	-	-	3
6.		Professional Elective VI	PEC	-	-	-	-	3
7.		Mandatory Course-II ^{&}	AC	3	0	0	3	0
8.		NCC Credit Course Level 3 [#]		3	0	0	3	
TOTAL				-	-	-	-	19

^{*}Open Elective – I Shall be chosen from the list of open electives offered by other Programmes

[&] Mandatory Course-II is a Non-credit Course (Student shall select one course from the list given under Mandatory Course-II)

[#] NCC Credit Course level 3 is offered for NCC students only. The grades earned by the students will be recorded in the Mark Sheet, however the same shall not be considered for the computation of CGPA

SEMESTER VII / VIII*

S. NO	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	GE3791	Human Values and Ethics	HSMC	2	0	0	2	2
2.		Elective - Management [#]	HSMC	3	0	0	3	3
3.		Open Elective – II**	OEC	3	0	0	3	3
4.		Open Elective – III**	OEC	3	0	0	3	3
5.		Open Elective – IV**	OEC	3	0	0	3	3
TOTAL				14	0	0	14	14

*If students undergo internship in Semester VII, then the courses offered during semester VII will be offered during semester VIII.

** Open Elective II - IV (Shall be chosen from the list of open electives offered by other Programmes).

[#] Elective - Management shall be chosen from the Elective Management courses.

SEMESTER VIII /VII*

S. NO	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
PRACTICALS								
1.	AD3811	Project Work / Internship	EEC	0	0	20	20	10
TOTAL				0	0	20	20	10

*If students undergo internship in Semester VII, then the courses offered during semester VII will be offered during semester VIII.

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TOTAL CREDITS: 163

ELECTIVE – MANAGEMENT COURSES

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	GE3751	Principles of Management	HSMC	3	0	0	3	3
2.	GE3752	Total Quality Management	HSMC	3	0	0	3	3
3.	GE3753	Engineering Economics and Financial Accounting	HSMC	3	0	0	3	3
4.	GE3754	Human Resource Management	HSMC	3	0	0	3	3
5.	GE3755	Knowledge Management	HSMC	3	0	0	3	3
6.	GE3792	Industrial Management	HSMC	3	0	0	3	3

MANDATORY COURSES I

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MX3081	Introduction to Women and Gender Studies	MC	3	0	0	3	0
2.	MX3082	Elements of Literature	MC	3	0	0	3	0
3.	MX3083	Film Appreciation	MC	3	0	0	3	0
4.	MX3084	Disaster Management	MC	3	0	0	3	0

MANDATORY COURSES II

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MX3085	Well Being with traditional practices (Yoga, Ayurveda and Siddha)	MC	3	0	0	3	0
2.	MX3086	History of Science and Technology in India	MC	3	0	0	3	0
3.	MX3087	Political and Economic Thought for a Humane Society	MC	3	0	0	3	0
4.	MX3088	State, Nation Building and Politics in India	MC	3	0	0	3	0
5.	MX3089	Industrial Safety	MC	3	0	0	3	0

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PROFESSIONAL ELECTIVE COURSES: VERTICALS

Vertical for AIDS I	Vertical II Full Stack Development for IT	Vertical III Cloud Computing and Data Centre Technologies	Vertical IV Cyber Security and Data Privacy	Vertical V Creative Media	Vertical VI Emerging Technologies	Vertical for AIDS II
Knowledge Engineering	Cloud Computing	Cloud Computing	Ethical Hacking	Augmented Reality/Virtual Reality	Augmented Reality/Virtual Reality	Bio-inspired Optimization Techniques
Recommender Systems	App Development	Virtualization	Digital and Mobile Forensics	Multimedia and Animation	Robotic Process Automation	App Development
Soft Computing	Cloud Services Management	Cloud Services Management	Social Network Security	Video Creation and Editing	Neural Networks and Deep Learning	Health care Analytics
Text and Speech Analysis	UI and UX Design	Data Warehousing	Modern Cryptography	UI and UX Design	Cyber security	Cyber security
Business Analytics	Software Testing and Automation	Storage Technologies	Engineering Secure Software Systems	Digital marketing	Quantum Computing	Optimization Techniques
Image and video analytics	Web Application Security	Software Defined Networks	Cryptocurrency and Blockchain Technologies	Multimedia Data Compression and Storage	Cryptocurrency and Blockchain Technologies	Game Theory
Computer Vision	Dev-ops	Stream Processing	Network Security	Game Development	Game Development	Cognitive Science
Big Data Analytics	Principles of Programming Languages	Security and Privacy in Cloud	Security and Privacy in Cloud	Visual Effects	3D Printing and Design	Ethics And AI

Registration of Professional Elective Courses from Verticals:

Professional Elective Courses will be registered in Semesters V and VI. These courses are listed in groups called verticals that represent a particular area of specialisation / diversified group. Students are permitted to choose all the Professional Electives from a particular vertical or from different verticals. Further, only one Professional Elective course shall be chosen in a semester horizontally (row-wise). However, two courses are permitted from the same row, provided one course is enrolled in Semester V and another in semester VI.

The registration of courses for B.E./B.Tech (Honours) or Minor degree shall be done from Semester V to VIII. The procedure for registration of courses explained above shall be followed for the courses of B.E./B.Tech (Honours) or Minor degree also. For more details on B.E./B.Tech (Honours) or Minor degree refer to the Regulations 2021, Clause 4.10.

PROFESSIONAL ELECTIVE COURSES: VERTICALS

VERTICAL 1: VERTICALS FOR AIDS I

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CCS350	Knowledge Engineering	PEC	2	0	2	4	3
2.	CCS360	Recommender Systems	PEC	2	0	2	4	3
3.	CCS364	Soft Computing	PEC	2	0	2	4	3
4.	CCS369	Text and Speech Analysis	PEC	2	0	2	4	3
5.	CCW331	Business Analytics	PEC	2	0	2	4	3
6.	CCS349	Image and video analytics	PEC	2	0	2	4	3
7.	CCS338	Computer Vision	PEC	2	0	2	4	3
8.	CCS334	Big Data Analytics	PEC	2	0	2	4	3

VERTICAL 2: FULL STACK DEVELOPMENT FOR IT

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CCS335	Cloud Computing	PEC	2	0	2	4	3
2.	CCS332	App Development	PEC	2	0	2	4	3
3.	CCS336	Cloud Services Management	PEC	2	0	2	4	3
4.	CCS370	UI and UX Design	PEC	2	0	2	4	3
5.	CCS366	Software Testing and Automation	PEC	2	0	2	4	3
6.	CCS374	Web Application Security	PEC	2	0	2	4	3
7.	CCS342	Dev-ops	PEC	2	0	2	4	3
8.	CCS358	Principles of Programming Languages	PEC	2	0	2	4	3

VERTICAL 3: CLOUD COMPUTING AND DATA CENTRE TECHNOLOGIES

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CCS335	Cloud Computing	PEC	2	0	2	4	3
2.	CCS372	Virtualization	PEC	2	0	2	4	3
3.	CCS336	Cloud Services Management	PEC	2	0	2	4	3
4.	CCS341	Data Warehousing	PEC	2	0	2	4	3
5.	CCS367	Storage Technologies	PEC	3	0	0	3	3
6.	CCS365	Software Defined Networks	PEC	2	0	2	4	3
7.	CCS368	Stream Processing	PEC	2	0	2	4	3
8.	CCS362	Security and Privacy in Cloud	PEC	2	0	2	4	3

VERTICAL 4: CYBER SECURITY AND DATA PRIVACY

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CCS344	Ethical Hacking	PEC	2	0	2	4	3
2.	CCS343	Digital and Mobile Forensics	PEC	2	0	2	4	3
3.	CCS363	Social Network Security	PEC	2	0	2	4	3
4.	CCS351	Modern Cryptography	PEC	2	0	2	4	3
5.	CB3591	Engineering Secure Software Systems	PEC	2	0	2	4	3
6.	CCS339	Cryptocurrency and Blockchain Technologies	PEC	2	0	2	4	3
7.	CCS354	Network Security	PEC	2	0	2	4	3
8.	CCS362	Security and Privacy in Cloud	PEC	2	0	2	4	3

VERTICAL 5: CREATIVE MEDIA

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CCS333	Augmented Reality/Virtual Reality	PEC	2	0	2	4	3
2.	CCS352	Multimedia and Animation	PEC	2	0	2	4	3
3.	CCS371	Video Creation and Editing	PEC	2	0	2	4	3
4.	CCS370	UI and UX Design	PEC	2	0	2	4	3
5.	CCW332	Digital marketing	PEC	2	0	2	4	3
6.	CCS353	Multimedia Data Compression and Storage	PEC	2	0	2	4	3
7.	CCS347	Game Development	PEC	2	0	2	4	3
8.	CCS373	Visual Effects	PEC	2	0	2	4	3

VERTICAL 6: EMERGING TECHNOLOGIES

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CCS333	Augmented Reality/Virtual Reality	PEC	2	0	2	4	3
2.	CCS361	Robotic Process Automation	PEC	2	0	2	4	3
3.	CCS355	Neural Networks and Deep Learning	PEC	2	0	2	4	3
4.	CCS340	Cyber security	PEC	2	0	2	4	3
5.	CCS359	Quantum Computing	PEC	2	0	2	4	3
6.	CCS339	Cryptocurrency and Blockchain Technologies	PEC	2	0	2	4	3
7.	CCS347	Game Development	PEC	2	0	2	4	3
8.	CCS331	3D Printing and Design	PEC	2	0	2	4	3

VERTICAL 7: VERTICALS FOR AIDS II

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	AD3001	Bio-inspired Optimization Techniques	PEC	2	0	2	4	3
2.	CCS332	App Development	PEC	2	0	2	4	3
3.	AD3002	Health care Analytics	PEC	2	0	2	4	3
4.	CCS340	Cyber security	PEC	2	0	2	4	3
5.	CCS357	Optimization Techniques	PEC	2	0	2	4	3
6.	CCS348	Game Theory	PEC	2	0	2	4	3
7.	CCS337	Cognitive Science	PEC	2	0	2	4	3
8.	CCS345	Ethics And AI	PEC	2	0	2	4	3

OPEN ELECTIVES

(Students shall choose the open elective courses, such that the course contents are not similar to any other course contents/title under other course categories).

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OPEN ELECTIVES – I

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	OAS351	Space Science	OEC	3	0	0	3	3
2.	OIE351	Introduction to Industrial Engineering	OEC	3	0	0	3	3
3.	OBT351	Climate Change and its Impact	OEC	3	0	0	3	3
4.	OCE351	Environment and Social Impact Assessment	OEC	3	0	0	3	3
5.	OEE351	Renewable Energy System	OEC	3	0	0	3	3
6.	OEI351	Introduction to Industrial Instrumentation and Control	OEC	3	0	0	3	3
7.	OMA351	Graph Theory	OEC	3	0	0	3	3

OPEN ELECTIVES – II

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	OIE352	Resource Management Techniques	OEC	3	0	0	3	3
2.	OMG351	Fintech Regulations	OEC	3	0	0	3	3
3.	OFD351	Holistic Nutrition	OEC	3	0	0	3	3
4.	OCE352	ICT in Agriculture	OEC	3	0	0	3	3
5.	OEI352	Introduction to Control Engineering	OEC	3	0	0	3	3
6.	OPY351	Pharmaceutical Nanotechnology	OEC	3	0	0	3	3
7.	OAE351	Aviation Management	OEC	3	0	0	3	3

OPEN ELECTIVES – III

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	OHS351	English for Competitive Examinations	OEC	3	0	0	3	3
2.	OMG352	NGOs and Sustainable Development	OEC	3	0	0	3	3
3.	OMG353	Democracy and Good Governance	OEC	3	0	0	3	3
4.	OME353	Renewable Energy Technologies	OEC	3	0	0	3	3
5.	OME354	Applied Design Thinking	OEC	2	0	2	4	3
6.	OMF351	Reverse Engineering	OEC	3	0	0	3	3
7.	OMF353	Sustainable Manufacturing	OEC	3	0	0	3	3
8.	OAU351	Electric and Hybrid Vehicle	OEC	3	0	0	3	3
9.	OAS352	Space Engineering	OEC	3	0	0	3	3
10.	OIM351	Industrial Management	OEC	3	0	0	3	3
11.	OIE354	Quality Engineering	OEC	3	0	0	3	3
12.	OSF351	Fire Safety Engineering	OEC	3	0	0	3	3
13.	OML351	Introduction to non-destructive testing	OEC	3	0	0	3	3
14.	OMR351	Mechatronics	OEC	3	0	0	3	3
15.	ORA351	Foundation of Robotics	OEC	3	0	0	3	3
16.	OAE352	Fundamentals of Aeronautical engineering	OEC	3	0	0	3	3
17.	OGI351	Remote Sensing Concepts	OEC	3	0	0	3	3
18.	OAI351	Urban Agriculture	OEC	3	0	0	3	3
19.	OEN351	Drinking Water Supply and Treatment	OEC	3	0	0	3	3
20.	OEE352	Electric Vehicle technology	OEC	3	0	0	3	3
21.	OEI353	Introduction to PLC	OEC	3	0	0	3	3

		Programming						
22.	OCH351	Nano Technology	OEC	3	0	0	3	3
23.	OCH352	Functional Materials	OEC	3	0	0	3	3
24.	OBT352	Biomedical Instrumentation	OEC	3	0	0	3	3
25.	OFD352	Traditional Indian Foods	OEC	3	0	0	3	3
26.	OFD353	Introduction to food processing	OEC	3	0	0	3	3
27.	OPY352	IPR for Pharma Industry	OEC	3	0	0	3	3
28.	OTT351	Basics of Textile Finishing	OEC	3	0	0	3	3
29.	OTT352	Industrial Engineering for Garment Industry	OEC	3	0	0	3	3
30.	OTT353	Basics of Textile Manufacture	OEC	3	0	0	3	3
31.	OPE351	Introduction to Petroleum Refining and Petrochemicals	OEC	3	0	0	3	3
32.	OPE352	Energy Conservation and Management	OEC	3	0	0	3	3
33.	OPT351	Basics of Plastics Processing	OEC	3	0	0	3	3
34.	OEC351	Signals and Systems	OEC	3	0	0	3	3
35.	OEC352	Fundamentals of Electronic Devices and Circuits	OEC	3	0	0	3	3
36.	OBM351	Foundation Skills in integrated product Development	OEC	3	0	0	3	3
37.	OBM352	Assistive Technology	OEC	3	0	0	3	3
38.	OMA352	Operations Research	OEC	3	0	0	3	3
39.	OMA353	Algebra and Number Theory	OEC	3	0	0	3	3
40.	OMA354	Linear Algebra	OEC	3	0	0	3	3
41.	OCE353	Lean Concepts, Tools And Practices	OEC	3	0	0	3	3

OPEN ELECTIVES – IV

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	OHS352	Project Report Writing	OEC	3	0	0	3	3
2.	OMA355	Advanced Numerical Methods	OEC	3	0	0	3	3
3.	OMA356	Random Processes	OEC	3	0	0	3	3
4.	OMA357	Queuing and Reliability Modelling	OEC	3	0	0	3	3
5.	OMG354	Production and Operations Management for Entrepreneurs	OEC	3	0	0	3	3
6.	OMG355	Multivariate Data Analysis	OEC	3	0	0	3	3

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7.	OME352	Additive Manufacturing	OEC	3	0	0	3	3
8.	OME353	New Product Development	OEC	3	0	0	3	3
9.	OME355	Industrial Design & Rapid Prototyping Techniques	OEC	2	0	2	4	3
10.	OMF352	Micro and Precision Engineering	OEC	3	0	0	3	3
11.	OMF354	Cost Management of Engineering Projects	OEC	3	0	0	3	3
12.	OAU352	Batteries and Management system	OEC	3	0	0	3	3
13.	OAU353	Sensors and Actuators	OEC	3	0	0	3	3
14.	OAS353	Space Vehicles	OEC	3	0	0	3	3
15.	OIM352	Management Science	OEC	3	0	0	3	3
16.	OIM353	Production Planning and Control	OEC	3	0	0	3	3
17.	OIE353	Operations Management	OEC	3	0	0	3	3
18.	OSF352	Industrial Hygiene	OEC	3	0	0	3	3
19.	OSF353	Chemical Process Safety	OEC	3	0	0	3	3
20.	OML352	Electrical, Electronic and Magnetic materials	OEC	3	0	0	3	3
21.	OML353	Nanomaterials and applications	OEC	3	0	0	3	3
22.	OMR352	Hydraulics and Pneumatics	OEC	3	0	0	3	3
23.	OMR353	Sensors	OEC	3	0	0	3	3
24.	ORA352	Foundation of Automation	OEC	3	0	0	3	3
25.	ORA353	Concepts in Mobile Robotics	OEC	3	0	0	3	3
26.	OMV351	Marine Propulsion	OEC	3	0	0	3	3
27.	OMV352	Marine Merchant Vehicles	OEC	3	0	0	3	3
28.	OMV353	Elements of Marine Engineering	OEC	3	0	0	3	3
29.	OAE353	Drone Technologies	OEC	3	0	0	3	3
30.	OGI352	Geographical Information System	OEC	3	0	0	3	3
31.	OAI352	Agriculture Entrepreneurship Development	OEC	3	0	0	3	3
32.	OEN352	Biodiversity Conservation	OEC	3	0	0	3	3
33.	OEE353	Introduction to control systems	OEC	3	0	0	3	3
34.	OEI354	Introduction to Industrial Automation Systems	OEC	3	0	0	3	3
35.	OCH353	Energy Technology	OEC	3	0	0	3	3
36.	OCH354	Surface Science	OEC	3	0	0	3	3
37.	OBT353	Environment and Agriculture	OEC	3	0	0	3	3
38.	OFD354	Fundamentals of Food Engineering	OEC	3	0	0	3	3
39.	OFD355	Food safety and Quality Regulations	OEC	3	0	0	3	3

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40.	OPY353	Nutraceuticals	OEC	3	0	0	3	3
41.	OTT354	Basics of Dyeing and Printing	OEC	3	0	0	3	3
42.	OTT355	Fibre Science	OEC	3	0	0	3	3
43.	OTT356	Garment Manufacturing Technology	OEC	3	0	0	3	3
44.	OPE353	Industrial safety	OEC	3	0	0	3	3
45.	OPE354	Unit Operations in Petro Chemical Industries	OEC	3	0	0	3	3
46.	OPT352	Plastic Materials for Engineers	OEC	3	0	0	3	3
47.	OPT353	Properties and Testing of Plastics	OEC	3	0	0	3	3
48.	OEC353	VLSI Design	OEC	3	0	0	3	3
49.	OEC354	Industrial IoT and Industry 4.0	OEC	2	0	2	4	3
50.	OBM353	Wearable devices	OEC	3	0	0	3	3
51.	OBM354	Medical Informatics	OEC	3	0	0	3	3
52.	OCE354	Basics of Integrated Water Resources Management	OEC	3	0	0	3	3

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PROGRESS THROUGH KNOWLEDGE

SUMMARY

Name of the Programme: B.Tech. Artificial Intelligence and Data Science										
S.No	Subject Area	Credits per Semester								Total Credits
		I	II	III	IV	V	VI	VII/VIII	VIII/VII	
1	HSMC	4	3					5		12
2	BSC	12	7	4	6					29
3	ESC	5	9							14
4	PCC		5	21	18	14	4			62
5	PEC					6	12			18
6	OEC						3	9		12
7	EEC	1	2	1		2			10	16
8	Non-Credit (Mandatory)					√	√			
Total		22	26	26	24	22	19	14	10	163

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ENROLLMENT FOR B.E. / B. TECH. (HONOURS) / MINOR DEGREE (OPTIONAL)

A student can also optionally register for additional courses (18 credits) and become eligible for the award of B.E. / B. Tech. (Honours) or Minor Degree.

For B.E. / B. Tech. (Honours), a student shall register for the additional courses (18 credits) from semester V onwards. These courses shall be from the same vertical or a combination of different verticals of the same programme of study only.

For minor degree, a student shall register for the additional courses (18 credits) from semester V onwards. All these courses have to be in a particular vertical from any one of the other programmes, Moreover, for minor degree the student can register for courses from any one of the following verticals also.

Complete details are available in clause 4.10 of Regulations 2021.

VERTICALS FOR MINOR DEGREE
(In addition to all the verticals of other programmes)

Vertical I Fintech and Block Chain	Vertical II Entrepreneurship	Vertical III Public Administration	Vertical IV Business Data Analytics	Vertical V Environmental and Sustainability
Financial Management	Foundations of Entrepreneurship	Principles of Public Administration	Statistics for Management	Sustainable infrastructure Development
Fundamentals of Investment	Team Building & Leadership Management for Business	Constitution of India	Datamining for Business Intelligence	Sustainable Agriculture and Environmental Management
Banking, Financial Services and Insurance	Creativity & Innovation in Entrepreneurship	Public Personnel Administration	Human Resource Analytics	Sustainable Bio Materials
Introduction to Blockchain and its Applications	Principles of Marketing Management for Business	Administrative Theories	Marketing and Social Media Web Analytics	Materials for Energy Sustainability
Fintech Personal Finance and Payments	Human Resource Management for Entrepreneurs	Indian Administrative System	Operation and Supply Chain Analytics	Green Technology
Introduction to Fintech	Financing New Business Ventures	Public Policy Administration	Financial Analytics	Environmental Quality Monitoring and Analysis
-	-	-	-	Integrated Energy Planning for Sustainable Development
-	-	-	-	Energy Efficiency for Sustainable Development



(choice of courses for Minor degree is to be made from any one vertical of other programmes or from anyone of the following verticals)

VERTICAL 1: FINTECH AND BLOCK CHAIN

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CMG331	Financial Management	PEC	3	0	0	3	3
2.	CMG332	Fundamentals of Investment	PEC	3	0	0	3	3
3.	CMG333	Banking, Financial Services and Insurance	PEC	3	0	0	3	3
4.	CMG334	Introduction to Blockchain and its Applications	PEC	3	0	0	3	3
5.	CMG335	Fintech Personal Finance and Payments	PEC	3	0	0	3	3
6.	CMG336	Introduction to Fintech	PEC	3	0	0	3	3

VERTICAL 2: ENTREPRENEURSHIP

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CMG337	Foundations of Entrepreneurship	PEC	3	0	0	3	3
2.	CMG338	Team Building & Leadership Management for Business	PEC	3	0	0	3	3
3.	CMG339	Creativity & Innovation in Entrepreneurship	PEC	3	0	0	3	3
4.	CMG340	Principles of Marketing Management For Business	PEC	3	0	0	3	3
5.	CMG341	Human Resource Management for Entrepreneurs	PEC	3	0	0	3	3
6.	CMG342	Financing New Business Ventures	PEC	3	0	0	3	3

VERTICAL 3: PUBLIC ADMINISTRATION

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CMG343	Principles of Public Administration	PEC	3	0	0	3	3
2.	CMG344	Constitution of India	PEC	3	0	0	3	3
3.	CMG345	Public Personnel Administration	PEC	3	0	0	3	3
4.	CMG346	Administrative Theories	PEC	3	0	0	3	3
5.	CMG347	Indian Administrative System	PEC	3	0	0	3	3
6.	CMG348	Public Policy Administration	PEC	3	0	0	3	3

VERTICAL 4: BUSINESS DATA ANALYTICS

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CMG349	Statistics for Management	PEC	3	0	0	3	3
2.	CMG350	Datamining For Business Intelligence	PEC	3	0	0	3	3
3.	CMG351	Human Resource Analytics	PEC	3	0	0	3	3
4.	CMG352	Marketing And Social Media Web Analytics	PEC	3	0	0	3	3
5.	CMG353	Operation And Supply Chain Analytics	PEC	3	0	0	3	3
6.	CMG354	Financial Analytics	PEC	3	0	0	3	3

PROGRESS THROUGH KNOWLEDGE

VERTICAL 5: ENVIRONMENTAL AND SUSTAINABILITY

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CES331	Sustainable infrastructure Development	PEC	3	0	0	3	3
2.	CES332	Sustainable Agriculture and Environmental Management	PEC	3	0	0	3	3
3.	CES333	Sustainable Bio Materials	PEC	3	0	0	3	3
4.	CES334	Materials for Energy Sustainability	PEC	3	0	0	3	3
5.	CES335	Green Technology	PEC	3	0	0	3	3
6.	CES336	Environmental Quality Monitoring and Analysis	PEC	3	0	0	3	3
7.	CES337	Integrated Energy Planning for Sustainable Development	PEC	3	0	0	3	3
8.	CES338	Energy Efficiency for Sustainable Development	PEC	3	0	0	3	3

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PROGRESS THROUGH KNOWLEDGE

MA3354

DISCRETE MATHEMATICS

L T P C
 3 1 0 4

COURSE OBJECTIVES:

- To extend student's logical and mathematical maturity and ability to deal with abstraction.
- To introduce most of the basic terminologies used in computer science courses and application of ideas to solve practical problems.
- To understand the basic concepts of combinatorics and graph theory.
- To familiarize the applications of algebraic structures.
- To understand the concepts and significance of lattices and boolean algebra which are widely used in computer science and engineering.

UNIT I LOGIC AND PROOFS

9 + 3

Propositional logic – Propositional equivalences - Predicates and quantifiers – Nested quantifiers – Rules of inference - Introduction to proofs – Proof methods and strategy.

UNIT II COMBINATORICS

9 + 3

Mathematical induction – Strong induction and well ordering – The basics of counting – The pigeonhole principle – Permutations and combinations – Recurrence relations – Solving linear recurrence relations – Generating functions – Inclusion and exclusion principle and its applications.

UNIT III GRAPHS

9 + 3

Graphs and graph models – Graph terminology and special types of graphs – Matrix representation of graphs and graph isomorphism – Connectivity – Euler and Hamilton paths.

UNIT IV ALGEBRAIC STRUCTURES

9 + 3

Algebraic systems – Semi groups and monoids - Groups – Subgroups – Homomorphism's – Normal subgroup and cosets – Lagrange's theorem – Definitions and examples of Rings and Fields.

UNIT V LATTICES AND BOOLEAN ALGEBRA

9 + 3

Partial ordering – Posets – Lattices as posets – Properties of lattices - Lattices as algebraic systems – Sub lattices – Direct product and homomorphism – Some special lattices – Boolean algebra – Sub Boolean Algebra – Boolean Homomorphism.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

At the end of the course, students would :

CO1:Have knowledge of the concepts needed to test the logic of a program.

CO2:Have an understanding in identifying structures on many levels.

CO3:Be aware of a class of functions which transform a finite set into another finite set which relates to input and output functions in computer science.

CO4:Be aware of the counting principles.

CO5:Be exposed to concepts and properties of algebraic structures such as groups, rings and fields.

TEXT BOOKS:

1. Rosen. K.H., "Discrete Mathematics and its Applications", 7th Edition, Tata McGraw Hill Pub. Co. Ltd., New Delhi, Special Indian Edition, 2017.
2. Tremblay. J.P. and Manohar. R, "Discrete Mathematical Structures with Applications to Computer Science", Tata McGraw Hill Pub. Co. Ltd, New Delhi, 30th Reprint, 2011.

REFERENCES:

1. Grimaldi. R.P. "Discrete and Combinatorial Mathematics: An Applied Introduction", 5th Edition, Pearson Education Asia, Delhi, 2013.
2. Koshy. T. "Discrete Mathematics with Applications", Elsevier Publications, 2006.
3. Lipschutz. S. and Mark Lipson., "Discrete Mathematics", Schaum's Outlines, Tata McGraw Hill Pub. Co. Ltd., New Delhi, 3rd Edition, 2010.

CS3351	DIGITAL PRINCIPLES AND COMPUTER ORGANIZATION	L T P C
		3 0 2 4

COURSE OBJECTIVES:

- To analyze and design combinational circuits.
- To analyze and design sequential circuits
- To understand the basic structure and operation of a digital computer.
- To study the design of data path unit, control unit for processor and to familiarize with the hazards.
- To understand the concept of various memories and I/O interfacing.

UNIT I COMBINATIONAL LOGIC 9

Combinational Circuits – Karnaugh Map - Analysis and Design Procedures – Binary Adder – Subtractor – Decimal Adder - Magnitude Comparator – Decoder – Encoder – Multiplexers - Demultiplexers

UNIT II SYNCHRONOUS SEQUENTIAL LOGIC 9

Introduction to Sequential Circuits – Flip-Flops – operation and excitation tables, Triggering of FF, Analysis and design of clocked sequential circuits – Design – Moore/Mealy models, state minimization, state assignment, circuit implementation - Registers – Counters.

UNIT III COMPUTER FUNDAMENTALS 9

Functional Units of a Digital Computer: Von Neumann Architecture – Operation and Operands of Computer Hardware Instruction – Instruction Set Architecture (ISA): Memory Location, Address and Operation – Instruction and Instruction Sequencing – Addressing Modes, Encoding of Machine Instruction – Interaction between Assembly and High Level Language.

UNIT IV PROCESSOR 9

Instruction Execution – Building a Data Path – Designing a Control Unit – Hardwired Control, Microprogrammed Control – Pipelining – Data Hazard – Control Hazards.

UNIT V MEMORY AND I/O

9

Memory Concepts and Hierarchy – Memory Management – Cache Memories: Mapping and Replacement Techniques – Virtual Memory – DMA – I/O – Accessing I/O: Parallel and Serial Interface – Interrupt I/O – Interconnection Standards: USB, SATA

45 PERIODS

PRACTICAL EXERCISES:

30 PERIODS

1. Verification of Boolean theorems using logic gates.
2. Design and implementation of combinational circuits using gates for arbitrary functions.
3. Implementation of 4-bit binary adder/subtractor circuits.
4. Implementation of code converters.
5. Implementation of BCD adder, encoder and decoder circuits
6. Implementation of functions using Multiplexers.
7. Implementation of the synchronous counters
8. Implementation of a Universal Shift register.
9. Simulator based study of Computer Architecture

COURSE OUTCOMES:

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

CO1 : Design various combinational digital circuits using logic gates

CO2 : Design sequential circuits and analyze the design procedures

CO3 : State the fundamentals of computer systems and analyze the execution of an instruction

CO4 : Analyze different types of control design and identify hazards

CO5 : Identify the characteristics of various memory systems and I/O communication

TOTAL:75 PERIODS

TEXT BOOKS

1. M. Morris Mano, Michael D. Ciletti, "Digital Design : With an Introduction to the Verilog HDL, VHDL, and System Verilog", Sixth Edition, Pearson Education, 2018.
2. David A. Patterson, John L. Hennessy, "Computer Organization and Design, The Hardware/Software Interface", Sixth Edition, Morgan Kaufmann/Elsevier, 2020.

REFERENCES

1. Carl Hamacher, Zvonko Vranesic, Safwat Zaky, Naraig Manjikian, "Computer Organization and Embedded Systems", Sixth Edition, Tata McGraw-Hill, 2012.
2. William Stallings, "Computer Organization and Architecture – Designing for Performance", Tenth Edition, Pearson Education, 2016.
3. M. Morris Mano, "Digital Logic and Computer Design", Pearson Education, 2016.

AD3391

DATABASE DESIGN AND MANAGEMENT

L T P C

3 0 0 3

COURSE OBJECTIVES:

- To introduce database development life cycle and conceptual modeling
- To learn SQL for data definition, manipulation and querying a database
- To learn relational database design using conceptual mapping and normalization

- To learn transaction concepts and serializability of schedules
- To learn data model and querying in object-relational and No-SQL databases

UNIT I	CONCEPTUAL DATA MODELING	8
Database environment – Database system development lifecycle – Requirements collection – Database design -- Entity-Relationship model – Enhanced-ER model – UML class diagrams.		
UNIT II	RELATIONAL MODEL AND SQL	10
Relational model concepts -- Integrity constraints -- SQL Data manipulation – SQL Data definition – Views -- SQL programming.		
UNIT III	RELATIONAL DATABASE DESIGN AND NORMALIZATION	10
ER and EER-to-Relational mapping – Update anomalies – Functional dependencies – Inference rules – Minimal cover – Properties of relational decomposition – Normalization (upto BCNF).		
UNIT IV	TRANSACTION MANAGEMENT	8
Transaction concepts – properties – Schedules – Serializability – Concurrency Control – Two-phase locking techniques.		
UNIT V	OBJECT RELATIONAL AND NO-SQL DATABASES	9
Mapping EER to ODB schema – Object identifier – reference types – rowtypes – UDTs – Subtypes and supertypes – user-defined routines – Collection types – Object Query Language; No-SQL: CAP theorem – Document-based: MongoDB data model and CRUD operations; Column-based: Hbase data model and CRUD operations.		

TOTAL : 45 PERIODS

COURSE OUTCOMES

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

- Understand the database development life cycle and apply conceptual modeling
- Apply SQL and programming in SQL to create, manipulate and query the database
- Apply the conceptual-to-relational mapping and normalization to design relational database
- Determine the serializability of any non-serial schedule using concurrency techniques
- Apply the data model and querying in Object-relational and No-SQL databases.

TEXT BOOKS:

1. Thomas M. Connolly, Carolyn E. Begg, Database Systems – A Practical Approach to Design, Implementation, and Management, Sixth Edition, Global Edition, Pearson Education, 2015.
2. Ramez Elmasri, Shamkant B. Navathe, Fundamentals of Database Systems, 7th Edition, Pearson, 2017.

REFERENCES:

1. Toby Teorey, Sam Lightstone, Tom Nadeau, H. V. Jagadish, “DATABASE MODELING AND DESIGN - Logical Design”, Fifth Edition, Morgan Kaufmann Publishers, 2011.
2. Carlos Coronel, Steven Morris, and Peter Rob, Database Systems: Design, Implementation, and Management, Ninth Edition, Cengage learning, 2012

3. Abraham Silberschatz, Henry F Korth, S Sudharshan, "Database System Concepts", 6th Edition, Tata Mc Graw Hill, 2011.
4. Hector Garcia-Molina, Jeffrey D Ullman, Jennifer Widom, "Database Systems:The Complete Book", 2nd edition, Pearson.
5. Raghu Ramakrishnan, "Database Management Systems", 4th Edition, Tata Mc Graw Hill, 2010.

AD3351 DESIGN AND ANALYSIS OF ALGORITHMS L T P C
3 0 2 4

COURSE OBJECTIVES:

- To critically analyze the efficiency of alternative algorithmic solutions for the same problem
- To illustrate brute force and divide and conquer design techniques.
- To explain dynamic programming and greedy techniques for solving various problems.
- To apply iterative improvement technique to solve optimization problems
- To examine the limitations of algorithmic power and handling it in different problems.

UNIT I INTRODUCTION 8

Notion of an Algorithm – Fundamentals of Algorithmic Problem Solving – Important Problem Types –Fundamentals of the Analysis of Algorithm Efficiency – Analysis Framework - Asymptotic Notations and their properties – Empirical analysis - Mathematical analysis of Recursive and Non-recursive algorithms – Visualization.

UNIT II BRUTE FORCE AND DIVIDE AND CONQUER 10

Brute Force – String Matching - Exhaustive Search - Traveling Salesman Problem - Knapsack Problem - Assignment problem. Divide and Conquer Methodology – Multiplication of Large Integers and Strassen’s Matrix Multiplication – Closest-Pair and Convex - Hull Problems. Decrease and Conquer: - Topological Sorting – Transform and Conquer: Presorting – Heaps and Heap Sort.

UNIT III DYNAMIC PROGRAMMING AND GREEDY TECHNIQUE 10

Dynamic programming – Principle of optimality - Coin changing problem – Warshall’s and Floyd’s algorithms – Optimal Binary Search Trees - Multi stage graph - Knapsack Problem and Memory functions. Greedy Technique – Dijkstra’s algorithm - Huffman Trees and codes - 0/1 Knapsack problem.

UNIT IV ITERATIVE IMPROVEMENT 8

The Simplex Method-The Maximum-Flow Problem – Maximum Matching in Bipartite Graphs- The Stable marriage Problem.

UNIT V LIMITATIONS OF ALGORITHM POWER 9

Lower - Bound Arguments - P, NP, NP- Complete and NP Hard Problems. Backtracking – N-Queen problem - Hamiltonian Circuit Problem – Subset Sum Problem. Branch and Bound – LIFO Search and FIFO search - Assignment problem – Knapsack Problem – Traveling Salesman Problem - Approximation Algorithms for NP-Hard Problems – Traveling Salesman problem – Knapsack problem.

TOTAL: 45 PERIODS

PRACTICAL EXERCISES:

1. Implement recursive and non-recursive algorithms and study the order of growth from $\log_2 n$ to $n!$.
2. Divide and Conquer - Strassen's Matrix Multiplication
3. Decrease and Conquer - Topological Sorting
4. Transform and Conquer - Heap Sort
5. Dynamic programming - Coin change Problem, Warshall's and Floyd's algorithms, Knapsack Problem
6. Greedy Technique – Dijkstra's algorithm, Huffman Trees and codes
7. Iterative improvement - Simplex Method
8. Backtracking – N-Queen problem, Subset Sum Problem
9. Branch and Bound - Assignment problem, Traveling Salesman Problem

TOTAL: 30 PERIODS

COURSE OUTCOMES:

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

CO1: Analyze the efficiency of recursive and non-recursive algorithms mathematically

CO2: Analyze the efficiency of brute force, divide and conquer, decrease and conquer, Transform and conquer algorithmic techniques

CO3: Implement and analyze the problems using dynamic programming and greedy algorithmic techniques.

CO4: Solve the problems using iterative improvement techniques for optimization.

CO5: Compute the limitations of algorithmic power and solve the problems using backtracking and branch and bound techniques.

TOTAL: 75 PERIODS

TEXT BOOKS:

1. Anany Levitin, Introduction to the Design and Analysis of Algorithms, Third Edition, Pearson Education, 2012.

REFERENCES:

1. Ellis Horowitz, Sartaj Sahni and Sanguthevar Rajasekaran, Computer Algorithms/ C++, Second Edition, Universities Press, 2019.
2. Thomas H.Cormen, Charles E.Leiserson, Ronald L. Rivest and Clifford Stein, Introduction to Algorithms, Third Edition, PHI Learning Private Limited, 2012.
3. S. Sridhar, Design and Analysis of Algorithms, Oxford university press, 2014.
4. Alfred V. Aho, John E. Hopcroft and Jeffrey D. Ullman, Data Structures and Algorithms, Pearson Education, Reprint 2006.

AD3301

DATA EXPLORATION AND VISUALIZATION

L T P C

3 0 2 4

OBJECTIVES:

- To outline an overview of exploratory data analysis.
- To implement data visualization using Matplotlib.
- To perform univariate data exploration and analysis.
- To apply bivariate data exploration and analysis.
- To use Data exploration and visualization techniques for multivariate and time series data.

UNIT I EXPLORATORY DATA ANALYSIS 9

EDA fundamentals – Understanding data science – Significance of EDA – Making sense of data – Comparing EDA with classical and Bayesian analysis – Software tools for EDA - Visual Aids for EDA- Data transformation techniques-merging database, reshaping and pivoting, Transformation techniques - Grouping Datasets - data aggregation – Pivot tables and cross-tabulations.

UNIT II VISUALIZING USING MATPLOTLIB 9

Importing Matplotlib – Simple line plots – Simple scatter plots – visualizing errors – density and contour plots – Histograms – legends – colors – subplots – text and annotation – customization – three dimensional plotting - Geographic Data with Basemap - Visualization with Seaborn.

UNIT III UNIVARIATE ANALYSIS 9

Introduction to Single variable: Distributions and Variables - Numerical Summaries of Level and Spread - Scaling and Standardizing – Inequality - Smoothing Time Series.

UNIT IV BIVARIATE ANALYSIS 9

Relationships between Two Variables - Percentage Tables - Analyzing Contingency Tables - Handling Several Batches - Scatterplots and Resistant Lines – Transformations.

UNIT V MULTIVARIATE AND TIME SERIES ANALYSIS 9

Introducing a Third Variable - Causal Explanations - Three-Variable Contingency Tables and Beyond - Longitudinal Data – Fundamentals of TSA – Characteristics of time series data – Data Cleaning – Time-based indexing – Visualizing – Grouping – Resampling.



PRACTICAL EXERCISES:

45 PERIODS

30 PERIODS

1. Install the data Analysis and Visualization tool: R/ Python /Tableau Public/ Power BI.
2. Perform exploratory data analysis (EDA) on with datasets like email data set. Export all your emails as a dataset, import them inside a pandas data frame, visualize them and get different insights from the data.
3. Working with Numpy arrays, Pandas data frames , Basic plots using Matplotlib.
4. Explore various variable and row filters in R for cleaning data. Apply various plot features in R on sample data sets and visualize.
5. Perform Time Series Analysis and apply the various visualization techniques.
6. Perform Data Analysis and representation on a Map using various Map data sets with Mouse Rollover effect, user interaction, etc..

7. Build cartographic visualization for multiple datasets involving various countries of the world; states and districts in India etc.
8. Perform EDA on Wine Quality Data Set.
9. Use a case study on a data set and apply the various EDA and visualization techniques and present an analysis report.

COURSE OUTCOMES:

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

CO1: Understand the fundamentals of exploratory data analysis.

CO2: Implement the data visualization using Matplotlib.

CO3: Perform univariate data exploration and analysis.

CO4: Apply bivariate data exploration and analysis.

CO5: Use Data exploration and visualization techniques for multivariate and time series data.

TOTAL: 75 PERIODS

TEXT BOOKS:

1. Suresh Kumar Mukhiya, Usman Ahmed, "Hands-On Exploratory Data Analysis with Python", Packt Publishing, 2020. (Unit 1)
2. Jake Vander Plas, "Python Data Science Handbook: Essential Tools for Working with Data", Oreilly, 1st Edition, 2016. (Unit 2)
3. Catherine Marsh, Jane Elliott, "Exploring Data: An Introduction to Data Analysis for Social Scientists", Wiley Publications, 2nd Edition, 2008. (Unit 3,4,5)

REFERENCES:

1. Eric Pimpler, Data Visualization and Exploration with R, GeoSpatial Training service, 2017.
2. Claus O. Wilke, "Fundamentals of Data Visualization", O'reilly publications, 2019.
3. Matthew O. Ward, Georges Grinstein, Daniel Keim, "Interactive Data Visualization: Foundations, Techniques, and Applications", 2nd Edition, CRC press, 2015.

AL3391

ARTIFICIAL INTELLIGENCE

**L T P C
3 0 0 3**

COURSE OBJECTIVES:

The main objectives of this course are to:

- Learn the basic AI approaches
- Develop problem solving agents
- Perform logical and probabilistic reasoning

UNIT I INTELLIGENT AGENTS

9

Introduction to AI – Agents and Environments – concept of rationality – nature of environments – structure of agents. Problem solving agents – search algorithms – uninformed search strategies.

UNIT II PROBLEM SOLVING

9

Heuristic search strategies – heuristic functions. Local search and optimization problems – local search in continuous space – search with non-deterministic actions – search in partially observable environments – online search agents and unknown environments

UNIT III GAME PLAYING AND CSP 9

Game theory – optimal decisions in games – alpha-beta search – monte-carlo tree search – stochastic games – partially observable games. Constraint satisfaction problems – constraint propagation – backtracking search for CSP – local search for CSP – structure of CSP.

UNIT IV LOGICAL REASONING 9

Knowledge-based agents – propositional logic – propositional theorem proving – propositional model checking – agents based on propositional logic. First-order logic – syntax and semantics – knowledge representation and engineering – inferences in first-order logic – forward chaining – backward chaining – resolution.

UNIT V PROBABILISTIC REASONING 9

Acting under uncertainty – Bayesian inference – naïve Bayes models. Probabilistic reasoning – Bayesian networks – exact inference in BN – approximate inference in BN – causal networks.

COURSE OUTCOMES:

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

- CO1: Explain intelligent agent frameworks
- CO2: Apply problem solving techniques
- CO3: Apply game playing and CSP techniques
- CO4: Perform logical reasoning
- CO5: Perform probabilistic reasoning under uncertainty

TOTAL:45 PERIODS

TEXT BOOKS:

1. Stuart Russell and Peter Norvig, “Artificial Intelligence – A Modern Approach”, Fourth Edition, Pearson Education, 2021.

REFERENCES

1. Dan W. Patterson, “Introduction to AI and ES”, Pearson Education, 2007
2. Kevin Night, Elaine Rich, and Nair B., “Artificial Intelligence”, McGraw Hill, 2008
3. Patrick H. Winston, "Artificial Intelligence", Third Edition, Pearson Education, 2006
4. Deepak Khemani, “Artificial Intelligence”, Tata McGraw Hill Education, 2013.
5. <http://nptel.ac.in/>

**AD3381 DATABASE DESIGN AND MANAGEMENT LABORATORY L T P C
0 0 3 1.5**

COURSE OBJECTIVES:

- To understand the database development life cycle
- To learn database design using conceptual modeling, Normalization
- To implement database using Data definition, Querying using SQL manipulation and SQL programming

- To implement database applications using IDE/RAD tools
- To learn querying Object-relational databases

SUGGESTIVE EXPERIMENTS

1. Database Development Life cycle:
 - Problem definition and Requirement analysis
 - Scope and Constraints
2. Database design using Conceptual modeling (ER-EER) – top-down approach
 - Mapping conceptual to relational database and validate using Normalization
3. Implement the database using SQL Data definition with constraints, Views
4. Query the database using SQL Manipulation
5. Querying/Managing the database using SQL Programming
 - Stored Procedures/Functions
 - Constraints and security using Triggers
6. Database design using Normalization – bottom-up approach
7. Develop database applications using IDE/RAD tools (Eg., NetBeans, VisualStudio)
8. Database design using EER-to-ODB mapping / UML class diagrams
9. Object features of SQL-UDTs and sub-types, Tables using UDTs, Inheritance, Method definition
10. Querying the Object-relational database using Object Query language

COURSE OUTCOMES

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

- Understand the database development life cycle
- Design relational database using conceptual-to-relational mapping, Normalization
- Apply SQL for creation, manipulation and retrieval of data
- Develop a database applications for real-time problems
- Design and query object-relational databases

TOTAL : 45 PERIODS

HARDWARE:

- Standalone Desktops

SOFTWARE:

- PostgreSQL

PROGRESS THROUGH KNOWLEDGE

AD3311

ARTIFICIAL INTELLIGENCE LABORATORY

L T P C
0 0 3 1.5

OBJECTIVES:

- To design and implement search strategies
- To implement game playing techniques
- To implement CSP techniques
- To develop systems with logical reasoning
- To develop systems with probabilistic reasoning

LIST OF EXPERIMENTS:

1. Implement basic search strategies – 8-Puzzle, 8 - Queens problem, Cryptarithmic.
2. Implement A* and memory bounded A* algorithms
3. Implement Minimax algorithm for game playing (Alpha-Beta pruning)
4. Solve constraint satisfaction problems
5. Implement propositional model checking algorithms
6. Implement forward chaining, backward chaining, and resolution strategies
7. Build naïve Bayes models
8. Implement Bayesian networks and perform inferences
9. Mini-Project

TOTAL: 45 PERIODS

OUTCOMES:

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

- CO1: Design and implement search strategies
CO2: Implement game playing and CSP techniques
CO3: Develop logical reasoning systems
CO4: Develop probabilistic reasoning systems

MA3391

PROBABILITY AND STATISTICS

L T P C
3 1 0 4

COURSE OBJECTIVES

- This course aims at providing the required skill to apply the statistical tools in engineering problems.
- To introduce the basic concepts of probability and random variables.
- To introduce the basic concepts of two dimensional random variables.
- To acquaint the knowledge of testing of hypothesis for small and large samples which plays an important role in real life problems.
- To introduce the basic concepts of classifications of design of experiments which plays very important roles in the field of agriculture and statistical quality control.

UNIT I PROBABILITY AND RANDOM VARIABLES

9 + 3

Axioms of probability – Conditional probability – Baye’s theorem - Discrete and continuous random variables – Moments – Moment generating functions – Binomial, Poisson, Geometric, Uniform, Exponential and Normal distributions – Functions of a random variable.

UNIT II TWO- DIMENSIONAL RANDOM VARIABLES

9 + 3

Joint distributions – Marginal and conditional distributions – Covariance – Correlation and linear regression – Transformation of random variables – Central limit theorem (for independent and identically distributed random variables).

UNIT III ESTIMATION THEORY

9 + 3

Unbiased estimators - Efficiency - Consistency - Sufficiency - Robustness - Method of moments - Method of maximum Likelihood - Interval estimation of Means - Differences between means,

variations and ratio of two variances

UNIT IV NON- PARAMETRIC TESTS

9 + 3

Introduction - The Sign test - The Signed - Rank test - Rank - sum tests - The U test - The H test - Tests based on Runs - Test of randomness - The Kolmogorov Tests .

UNIT V STATISTICAL QUALITY CONTROL

9 + 3

Control charts for measurements (\bar{x} and R charts) – Control charts for attributes (p, c and np charts) – Tolerance limits - Acceptance sampling.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

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

- Understand the fundamental knowledge of the concepts of probability and have knowledge of standard distributions which can describe real life phenomenon.
- Understand the basic concepts of one and two dimensional random variables and apply in engineering applications.
- Apply the concept of testing of hypothesis for small and large samples in real life problems.
- Apply the basic concepts of classifications of design of experiments in the field of agriculture and statistical quality control.
- Have the notion of sampling distributions and statistical techniques used in engineering and management problems.

TEXT BOOKS

1. Johnson. R.A., Miller. I.R. and Freund. J.E., " Miller and Freund's Probability and Statistics for Engineers", Pearson Education, Asia, 9th Edition, 2016.
2. Milton. J. S. and Arnold. J.C., "Introduction to Probability and Statistics", Tata Mc Graw Hill, 4th Edition, 2007.
3. John E. Freund, "Mathematical Statistics", Prentice Hall, 5th Edition, 1992.

REFERENCES:

1. Gupta. S.C. and Kapoor. V. K., "Fundamentals of Mathematical Statistics", Sultan Chand & Sons, New Delhi, 12th Edition, 2020.
2. Devore. J.L., "Probability and Statistics for Engineering and the Sciences", Cengage Learning, New Delhi, 8th Edition, 2014.
3. Ross. S.M., "Introduction to Probability and Statistics for Engineers and Scientists", 5th Edition, Elsevier, 2014.
4. Spiegel. M.R., Schiller. J. and Srinivasan. R.A., "Schaum's Outline of Theory and Problems of Probability and Statistics", Tata McGraw Hill Edition, 4th Edition, 2012.
5. Walpole. R.E., Myers. R.H., Myers. S.L. and Ye. K., "Probability and Statistics for Engineers and Scientists", Pearson Education, Asia, 9th Edition, 2010.

AL3452

OPERATING SYSTEMS

L T P C

3 0 2 4

COURSE OBJECTIVES:

- To understand the basics and functions of operating systems.
- To understand Processes and Threads
- To analyze Scheduling algorithms and process synchronization.
- To understand the concept of Deadlocks.
- To analyze various memory management schemes.
- To be familiar with I/O management and File systems.
- To be familiar with the basics of virtual machines and Mobile OS like iOS and Android.

UNIT I INTRODUCTION

7

Computer System - Elements and organization; Operating System Overview - Objectives and Functions - Evolution of Operating System; Operating System Structures – Operating System Services - User Operating System Interface - System Calls – System Programs - Design and Implementation - Structuring methods.

UNIT II PROCESS MANAGEMENT

11

Processes - Process Concept - Process Scheduling - Operations on Processes - Inter-process Communication; CPU Scheduling - Scheduling criteria - Scheduling algorithms: Threads - Multithread Models – Threading issues; Process Synchronization - The critical-section problem - Synchronization hardware – Semaphores – Mutex - Classical problems of synchronization - Monitors; Deadlock - Methods for handling deadlocks, Deadlock prevention, Deadlock avoidance, Deadlock detection, Recovery from deadlock.

UNIT III MEMORY MANAGEMENT

10

Main Memory - Swapping - Contiguous Memory Allocation – Paging - Structure of the Page Table - Segmentation, Segmentation with paging; Virtual Memory - Demand Paging – Copy on Write - Page Replacement - Allocation of Frames –Thrashing.

UNIT IV STORAGE MANAGEMENT

10

Mass Storage system – Disk Structure - Disk Scheduling and Management; File-System Interface - File concept - Access methods - Directory Structure - Directory organization - File system mounting - File Sharing and Protection; File System Implementation - File System Structure - Directory implementation - Allocation Methods - Free Space Management; I/O Systems – I/O Hardware, Application I/O interface, Kernel I/O subsystem.

UNIT V VIRTUAL MACHINES AND MOBILE OS

7

Virtual Machines – History, Benefits and Features, Building Blocks, Types of Virtual Machines and their Implementations, Virtualization and Operating-System Components; Mobile OS - iOS and Android.

45 PERIODS

PRACTICAL EXERCISES:

30 PERIODS

1. Installation of Operating system : Windows/ Linux

2. Illustrate UNIX commands and Shell Programming
3. Process Management using System Calls : Fork, Exec, Getpid, Exit, Wait, Close
4. Write C programs to implement the various CPU Scheduling Algorithms
5. Illustrate the inter process communication strategy
6. Implement mutual exclusion by Semaphores
7. Write a C program to avoid Deadlock using Banker's Algorithm
8. Write a C program to Implement Deadlock Detection Algorithm
9. Write C program to implement Threading
10. Implement the paging Technique using C program
1. Write C programs to implement the following Memory Allocation Methods
 - a. First Fit
 - b. Worst Fit
 - c. Best Fit
2. Write C programs to implement the various Page Replacement Algorithms
3. Write C programs to Implement the various File Organization Techniques
4. Implement the following File Allocation Strategies using C programs
 - a. Sequential
 - b. Indexed
 - c. Linked
5. Write C programs for the implementation of various disk scheduling algorithms

COURSE OUTCOMES:

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

CO1: Analyze various scheduling algorithms and process synchronization.

CO2 : Explain deadlock, prevention and avoidance algorithms.

CO3 : Compare and contrast various memory management schemes.

CO4 : Explain the functionality of file systems I/O systems, and Virtualization

CO5 : Compare iOS and Android Operating Systems.

TOTAL:75 PERIODS

TEXTBOOKS

1. Abraham Silberschatz, Peter Baer Galvin and Greg Gagne, "Operating System Concepts", 9th Edition, John Wiley and Sons Inc., 2018.
2. Andrew S Tanenbaum, "Modern Operating Systems", Pearson, 4th Edition, New Delhi, 2016.

REFERENCES

1. Ramaz Elmasri, A. Gil Carrick, David Levine, "Operating Systems – A Spiral Approach", Tata McGraw Hill Edition, 2010.
2. William Stallings, "Operating Systems: Internals and Design Principles", 7th Edition, Prentice Hall, 2018.
3. Achyut S.Godbole, Atul Kahate, "Operating Systems", McGraw Hill Education, 2016.

AL3451

MACHINE LEARNING

L T P C

3 0 0 3

COURSE OBJECTIVES:

- To understand the basic concepts of machine learning.
- To understand and build supervised learning models.
- To understand and build unsupervised learning models.
- To evaluate the algorithms based on corresponding metrics identified

UNIT I INTRODUCTION TO MACHINE LEARNING 8

Review of Linear Algebra for machine learning; Introduction and motivation for machine learning; Examples of machine learning applications, Vapnik-Chervonenkis (VC) dimension, Probably Approximately Correct (PAC) learning, Hypothesis spaces, Inductive bias, Generalization, Bias variance trade-off.

UNIT II SUPERVISED LEARNING 11

Linear Regression Models: Least squares, single & multiple variables, Bayesian linear regression, gradient descent, Linear Classification Models: Discriminant function – Perceptron algorithm, Probabilistic discriminative model - Logistic regression, Probabilistic generative model – Naive Bayes, Maximum margin classifier – Support vector machine, Decision Tree, Random Forests

UNIT III ENSEMBLE TECHNIQUES AND UNSUPERVISED LEARNING 9

Combining multiple learners: Model combination schemes, Voting, Ensemble Learning - bagging, boosting, stacking, Unsupervised learning: K-means, Instance Based Learning: KNN, Gaussian mixture models and Expectation maximization.

UNIT IV NEURAL NETWORKS 9

Multilayer perceptron, activation functions, network training – gradient descent optimization – stochastic gradient descent, error backpropagation, from shallow networks to deep networks – Unit saturation (aka the vanishing gradient problem) – ReLU, hyperparameter tuning, batch normalization, regularization, dropout.

UNIT V DESIGN AND ANALYSIS OF MACHINE LEARNING EXPERIMENTS 8

Guidelines for machine learning experiments, Cross Validation (CV) and resampling – K-fold CV, bootstrapping, measuring classifier performance, assessing a single classification algorithm and comparing two classification algorithms – t test, McNemar's test, K-fold CV paired t test

COURSE OUTCOMES:

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

- CO1: Explain the basic concepts of machine learning.
- CO2 : Construct supervised learning models.
- CO3 : Construct unsupervised learning algorithms.
- CO4: Evaluate and compare different models

TOTAL:45 PERIODS

TEXTBOOKS:

1. Ethem Alpaydin, "Introduction to Machine Learning", MIT Press, Fourth Edition, 2020.
2. Stephen Marsland, "Machine Learning: An Algorithmic Perspective, "Second Edition", CRC Press, 2014.

REFERENCES:

1. Christopher M. Bishop, "Pattern Recognition and Machine Learning", Springer, 2006.
2. Tom Mitchell, "Machine Learning", McGraw Hill, 3rd Edition, 1997.
3. Mehryar Mohri, Afshin Rostamizadeh, Ameet Talwalkar, "Foundations of Machine Learning", Second Edition, MIT Press, 2012, 2018.
4. Ian Goodfellow, Yoshua Bengio, Aaron Courville, "Deep Learning", MIT Press, 2016
5. Sebastain Raschka, Vahid Mirjalili , "Python Machine Learning", Packt publishing, 3rd Edition, 2019.

AD3491

FUNDAMENTALS OF DATA SCIENCE AND ANALYTICS

L T P C

3 0 0 3

OBJECTIVES:

- To understand the techniques and processes of data science
- To apply descriptive data analytics
- To visualize data for various applications
- To understand inferential data analytics
- To analysis and build predictive models from data

UNIT I INTRODUCTION TO DATA SCIENCE 08

Need for data science – benefits and uses – facets of data – data science process – setting the research goal – retrieving data – cleansing, integrating, and transforming data – exploratory data analysis – build the models – presenting and building applications.

UNIT II DESCRIPTIVE ANALYTICS 10

Frequency distributions – Outliers –interpreting distributions – graphs – averages - describing variability – interquartile range – variability for qualitative and ranked data - Normal distributions – z scores –correlation – scatter plots – regression – regression line – least squares regression line – standard error of estimate – interpretation of r^2 – multiple regression equations – regression toward the mean.

UNIT III INFERENTIAL STATISTICS 09

Populations – samples – random sampling – Sampling distribution- standard error of the mean - Hypothesis testing – z-test – z-test procedure –decision rule – calculations – decisions – interpretations - one-tailed and two-tailed tests – Estimation – point estimate – confidence interval – level of confidence – effect of sample size.

UNIT IV ANALYSIS OF VARIANCE 09

t-test for one sample – sampling distribution of t – t-test procedure – t-test for two independent samples – p-value – statistical significance – t-test for two related samples. F-test – ANOVA – Two-factor experiments – three f-tests – two-factor ANOVA –Introduction to chi-square tests.

UNIT V PREDICTIVE ANALYTICS 09

Linear least squares – implementation – goodness of fit – testing a linear model – weighted resampling. Regression using StatsModels – multiple regression – nonlinear relationships – logistic regression – estimating parameters – Time series analysis – moving averages – missing values – serial correlation – autocorrelation. Introduction to survival analysis.

TOTAL : 45 PERIODS

OUTCOMES:

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

- CO1:** Explain the data analytics pipeline
- CO2:** Describe and visualize data
- CO3 :** Perform statistical inferences from data
- CO4 :** Analyze the variance in the data
- CO5 :** Build models for predictive analytics

TEXT BOOKS

1. David Cielen, Arno D. B. Meysman, and Mohamed Ali, "Introducing Data Science", Manning Publications, 2016. (first two chapters for Unit I).
2. Robert S. Witte and John S. Witte, "Statistics", Eleventh Edition, Wiley Publications, 2017.
3. Jake VanderPlas, "Python Data Science Handbook", O'Reilly, 2016.

REFERENCES

1. Allen B. Downey, "Think Stats: Exploratory Data Analysis in Python", Green Tea Press, 2014.
2. Sanjeev J. Wagh, Manisha S. Bhende, Anuradha D. Thakare, "Fundamentals of Data Science", CRC Press, 2022.
3. Chirag Shah, "A Hands-On Introduction to Data Science", Cambridge University Press, 2020.
4. Vineet Raina, Srinath Krishnamurthy, "Building an Effective Data Science Practice: A Framework to Bootstrap and Manage a Successful Data Science Practice", Apress, 2021.

CS3591

COMPUTER NETWORKS

L T P C
3 0 2 4

COURSE OBJECTIVES:

- To understand the concept of layering in networks.
- To know the functions of protocols of each layer of TCP/IP protocol suite.
- To visualize the end-to-end flow of information.
- To learn the functions of network layer and the various routing protocols
- To familiarize the functions and protocols of the Transport layer

UNIT I INTRODUCTION AND APPLICATION LAYER 10

Data Communication - Networks – Network Types – Protocol Layering – TCP/IP Protocol suite – OSI Model – Introduction to Sockets - Application Layer protocols: HTTP – FTP – Email protocols (SMTP - POP3 - IMAP - MIME) – DNS – SNMP

UNIT II TRANSPORT LAYER 9

Introduction - Transport-Layer Protocols: UDP – TCP: Connection Management – Flow control - Congestion Control - Congestion avoidance (DECbit, RED) – SCTP – Quality of Service

UNIT III NETWORK LAYER 7

Switching : Packet Switching - Internet protocol - IPV4 – IP Addressing – Subnetting - IPV6, ARP, RARP, ICMP, DHCP

UNIT IV ROUTING 7

Routing and protocols: Unicast routing - Distance Vector Routing - RIP - Link State Routing – OSPF – Path-vector routing - BGP - Multicast Routing: DVMRP – PIM.

UNIT V DATA LINK AND PHYSICAL LAYERS

12

Data Link Layer – Framing – Flow control – Error control – Data-Link Layer Protocols – HDLC – PPP - Media Access Control – Ethernet Basics – CSMA/CD – Virtual LAN – Wireless LAN (802.11) - Physical Layer: Data and Signals - Performance – Transmission media- Switching – Circuit Switching.

45 PERIODS

PRACTICAL EXERCISES:

30 PERIODS

1. Learn to use commands like tcpdump, netstat, ifconfig, nslookup and traceroute. Capture ping and trace route PDUs using a network protocol analyzer and examine.
2. Write a HTTP web client program to download a web page using TCP sockets.
3. Applications using TCP sockets like: a) Echo client and echo server b) Chat
4. Simulation of DNS using UDP sockets.
5. Use a tool like Wireshark to capture packets and examine the packets
6. Write a code simulating ARP /RARP protocols.
7. Study of Network simulator (NS) and Simulation of Congestion Control Algorithms using NS.
8. Study of TCP/UDP performance using Simulation tool.
9. Simulation of Distance Vector/ Link State Routing algorithm.
10. Simulation of an error correction code (like CRC)

COURSE OUTCOMES:

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

CO 1: Explain the basic layers and its functions in computer networks.

CO 2: Understand the basics of how data flows from one node to another.

CO 3: Analyze routing algorithms.

CO 4: Describe protocols for various functions in the network.

CO 5: Analyze the working of various application layer protocols.

TOTAL:75 PERIODS

TEXT BOOKS

1. James F. Kurose, Keith W. Ross, Computer Networking, A Top-Down Approach Featuring the Internet, Eighth Edition, Pearson Education, 2021.
2. Behrouz A. Forouzan, Data Communications and Networking with TCP/IP Protocol Suite, Sixth Edition TMH, 2022

REFERENCES

1. Larry L. Peterson, Bruce S. Davie, Computer Networks: A Systems Approach, Fifth Edition, Morgan Kaufmann Publishers Inc., 2012.
2. William Stallings, Data and Computer Communications, Tenth Edition, Pearson Education, 2013.
3. Nader F. Mir, Computer and Communication Networks, Second Edition, Prentice Hall, 2014.
4. Ying-Dar Lin, Ren-Hung Hwang, Fred Baker, "Computer Networks: An Open Source Approach", McGraw Hill, 2012.

GE3451

ENVIRONMENTAL SCIENCES AND SUSTAINABILITY

L T P C

2 0 0 2

UNIT I ENVIRONMENT AND BIODIVERSITY 6

Definition, scope and importance of environment – need for public awareness. Eco-system and Energy flow– ecological succession. Types of biodiversity: genetic, species and ecosystem diversity– values of biodiversity, India as a mega-diversity nation – hot-spots of biodiversity – threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts – endangered and endemic species of India – conservation of biodiversity: In-situ and ex-situ.

UNIT II ENVIRONMENTAL POLLUTION 9

Causes, Effects and Preventive measures of Water, Soil, Air and Noise Pollutions. Solid, Hazardous and E-Waste management. Case studies on Occupational Health and Safety Management system (OHASMS). Environmental protection, Environmental protection acts .

UNIT III RENEWABLE SOURCES OF ENERGY 6

Energy management and conservation, New Energy Sources: Need of new sources. Different types new energy sources. Applications of- Hydrogen energy, Ocean energy resources, Tidal energy conversion. Concept, origin and power plants of geothermal energy.

UNIT IV SUSTAINABILITY AND MANAGEMENT 6

Development , GDP ,Sustainability- concept, needs and challenges-economic, social and aspects of sustainability-from unsustainability to sustainability-millennium development goals, and protocols-Sustainable Development Goals-targets, indicators and intervention areas Climate change- Global, Regional and local environmental issues and possible solutions-case studies. Concept of Carbon Credit, Carbon Footprint. Environmental management in industry-A case study.

UNIT V SUSTAINABILITY PRACTICES 6

Zero waste and R concept, Circular economy, ISO 14000 Series, Material Life cycle assessment, Environmental Impact Assessment. Sustainable habitat: Green buildings, Green materials, Energy efficiency, Sustainable transports. Sustainable energy: Non-conventional Sources, Energy Cycles-carbon cycle, emission and sequestration, Green Engineering: Sustainable urbanization- Socio-economical and technological change.

TOTAL: 30 PERIODS

TEXT BOOKS:

1. Anubha Kaushik and C. P. Kaushik's "Perspectives in Environmental Studies", 6th Edition, New Age International Publishers ,2018.
2. Benny Joseph, 'Environmental Science and Engineering', Tata McGraw-Hill, New Delhi, 2016.
3. Gilbert M.Masters, 'Introduction to Environmental Engineering and Science', 2nd edition, Pearson Education, 2004.
4. Allen, D. T. and Shonnard, D. R., Sustainability Engineering: Concepts, Design and Case Studies, Prentice Hall.

5. Bradley. A.S; Adebayo, A.O., Maria, P. Engineering applications in sustainable design and development, Cengage learning.
6. Environment Impact Assessment Guidelines, Notification of Government of India, 2006.
7. Mackenthun, K.M., Basic Concepts in Environmental Management, Lewis Publication, London, 1998.

REFERENCES :

1. R.K. Trivedi, 'Handbook of Environmental Laws, Rules, Guidelines, Compliances and Standards', Vol. I and II, Enviro Media. 38 . edition 2010.
2. Cunningham, W.P. Cooper, T.H. Gorhani, 'Environmental Encyclopedia', Jaico Publ., House, Mumbai, 2001.
3. Dharmendra S. Sengar, 'Environmental law', Prentice hall of India PVT. LTD, New Delhi, 2007.
4. Rajagopalan, R, 'Environmental Studies-From Crisis to Cure', Oxford University Press, Third Edition, 2015.
5. Erach Bharucha "Textbook of Environmental Studies for Undergraduate Courses" Orient Blackswan Pvt. Ltd. 2013.

AD3411

DATA SCIENCE AND ANALYTICS LABORATORY

L T P C
0 0 4 2

OBJECTIVES:

- To develop data analytic code in python
- To be able to use python libraries for handling data
- To develop analytical applications using python
- To perform data visualization using plots

LIST OF EXPERIMENTS

Tools: Python, Numpy, Scipy, Matplotlib, Pandas, statmodels, seaborn, plotly, bokeh

Working with Numpy arrays

1. Working with Pandas data frames
2. Basic plots using Matplotlib
3. Frequency distributions, Averages, Variability
4. Normal curves, Correlation and scatter plots, Correlation coefficient
5. Regression
6. Z-test
7. T-test
8. ANOVA
9. Building and validating linear models
10. Building and validating logistic models
11. Time series analysis

PRACTICALS 60 PERIODS

OUTCOMES:

Upon successful completion of this course, students will be able to:

- CO1. Write python programs to handle data using Numpy and Pandas
- CO2. Perform descriptive analytics
- CO3. Perform data exploration using Matplotlib
- CO4. Perform inferential data analytics
- CO5. Build models of predictive analytics

REFERENCES

1. Jake VanderPlas, “Python Data Science Handbook”, O’Reilly, 2016.
2. Allen B. Downey, “Think Stats: Exploratory Data Analysis in Python”, Green Tea Press, 2014.
3. Data Analysis and Visualization Using Python, Analyze Data to Create Visualizations for BI Systems — Dr. Ossama Embarak

AL3461

MACHINE LEARNING LABORATORY

L T P C
0 0 4 2

OBJECTIVES:

- To understand the data sets and apply suitable algorithms for selecting the appropriate features for analysis.
- To learn to implement supervised machine learning algorithms on standard datasets and evaluate the performance.
- To experiment the unsupervised machine learning algorithms on standard datasets and evaluate the performance.
- To build the graph based learning models for standard data sets.
- To compare the performance of different ML algorithms and select the suitable one based on the application.

LIST OF EXPERIMENTS:

1. For a given set of training data examples stored in a .CSV file, implement and demonstrate the **Candidate-Elimination algorithm** to output a description of the set of all hypotheses consistent with the training examples.
2. Write a program to demonstrate the working of the decision tree based **ID3 algorithm**. Use an appropriate data set for building the decision tree and apply this knowledge to classify a new sample.
3. Build an Artificial Neural Network by implementing the **Backpropagation algorithm** and test the same using appropriate data sets.
4. Write a program to implement the **naïve Bayesian classifier** for a sample training data set stored as a .CSV file and compute the accuracy with a few test data sets.
5. Implement **naïve Bayesian Classifier** model to classify a set of documents and measure the accuracy, precision, and recall.
6. Write a program to construct a **Bayesian network** to diagnose CORONA infection using standard WHO Data Set.
7. Apply **EM algorithm** to cluster a set of data stored in a .CSV file. Use the same data set for clustering using the k-Means **algorithm**. Compare the results of these two algorithms.
8. Write a program to implement **k-Nearest Neighbour algorithm** to classify the iris data set. Print both correct and wrong predictions.

9. Implement the non-parametric **Locally Weighted Regression algorithm** in order to fit data points. Select an appropriate data set for your experiment and draw graphs.

List of Equipments:(30 Students per Batch)

The programs can be implemented in either Python or R.

TOTAL:60 PERIODS

OUTCOMES:

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

CO1:Apply suitable algorithms for selecting the appropriate features for analysis.

CO2:Implement supervised machine learning algorithms on standard datasets and evaluate the performance.

CO3:Apply unsupervised machine learning algorithms on standard datasets and evaluate the performance.

CO4:Build the graph based learning models for standard data sets.

CO5:Assess and compare the performance of different ML algorithms and select the suitable one based on the application.

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