Fifth Semester

Group	Paper Code	Paper Title	L	P	Credits
Theory Papers					
DSC	ARD301	Data Warehouse and Data Lakes	4	-	4
DSC	ARD303	Data Visualization	3	-	3
DSC	ARD305	Containerized Data Processing Pipelines	3	-	3
MSC	As per MSC list	One MSC course from the MSC List as per the decision of the APC (Academic Program Committee) of the school/institute (MSC-I)	3	-	3
MSC	As per MSC list	One MSC from the MSC List as per the decision of the APC (Academic Program Committee) of the school/institute (MSC-II)	As per MSC list	-	As per MSC list
Practical/Viva-Voce					
DSC	ARD351	Data Visualization Lab	-	2	1
DSC	ARD353	Containerized Data Processing Pipelines Lab	-	2	1
MSC	As per MSC list	MSC-I Lab	-	2	1
MSC	As per MSC list	MSC-II Lab	-	As per MSC list	As per MSC list
SI	ARD361	Summer Internship - I## (NUES)	-	2	2
					22

 # (NUES): Non-University Exam Subject, Comprehensive evaluation by the concerned teacher, out of 100, as per detailed syllabus.

Sixth Semester

Group	Paper Code	Paper Title	L	P	Credits
Theory Papers					
DSC	ARD302	MLOps & Model Deployment	3	-	3
DSC	ARD304	Time Series Modeling and Forecasting	3	-	3
DSC	ARD306	Big Data Analytics	3	-	3
DSC	ARD308	Deep Learning	3	-	3
MSC	As per MSC list	One MSC from the MSC List as per the decision of the APC (Academic Program Committee) of the school/institute (MSC-III)	As per MSC list	-	As per MSC list
MSC	As per MSC list	One MSC course from the MSC List as per the decision of the APC (Academic Program Committee) of the school/institute (MSC-IV)	-	-	2
Practical/Viva-Voce					
DSC	ARD354	MLOps & Model Deployment Lab	-	2	1
DSC	ARD356	Time Series Modeling and Forecasting Lab	-	2	1
DSC	ARD358	Big data Analytics Lab	-	2	1
DSC	ARD360	Deep Learning Lab	-	2	1

MSC	As per MSC list	MSC-III Lab	-	As per MSC list	As per MSC list
MSC	As per MSC list	MSC-IV Lab	-	2	1
					22

NCC/NSS/DSW Clubs/Non-Tech Clubs/Tech Clubs/Societies	ARD352	NCC/NSS/ Club/ DSW Clubs / USAR Tech and Non Tech Clubs (NUES)	-	-	2

Students are supposed to enroll for Summer Internship (SI w.r.t. ARD465) upon completion of 6th semester and whose evaluation will be performed towards the end of 7th Semester.

Seventh Semester

Theory Papers					
Group	**Paper Code**	**Paper Title**	**L**	**P**	**Credits**
DSC	ARD401	Reinforcement Learning	3	-	3
DSC	ARD403	Recommender System	3	-	3
DSC	ARD405	Cloud Dew Edge Fog (CDEF) Computing	3	-	3
MSC	As per MSC list	One MSC course from the MSC List as per the decision of the APC (Academic Program Committee) of the school/institute (MSC-V)	2	-	2
MSC	As per MSC list	One MSC course from the MSC List as per the decision of the APC (Academic Program Committee) of the school/institute (MSC-VI)	2	-	2
Practical/Viva-Voce					
DSC	ARD453	Recommender System Lab	-	2	1
DSC	ARD455	Cloud Dew Edge Fog (CDEF) Computing Lab	-	2	1
MSC	As per MSC list	MSC-V Lab	-	2	1
MSC	As per MSC list	MSC-VI Lab	-	2	1
SI	ARD465	Summer Internship - II[##](NUES)	-	-	2
DSC	ARD467	Minor Project**	-	-	3
					22

Comprehensive evaluation by a committee of teachers, constituted by the Academic Programme Committee (APC), out of 100. The training shall be of 4 to 6 weeks duration. The training can be under the mentorship of a teacher of the school/institute.

*** The student shall be allocated a supervisor/guide for project work at the start of 7th semester by the school/institute, preferably, the project can be continued into the 8th semester. In the 7th semester evaluation, the criteria for evaluation shall be the conceptualization of the project work, the background study/literature survey and the identification of objectives and methodology to be followed for the*

project. In the absence of the supervisor, the Dean/Director/Principal of the school/institute can assign the responsibility of the supervisor (for the purpose of examinations) to any faculty of the school/institute. The internal and external bifurcation of the project marks will be as per the bifurcation of marks for the practical examination.

Students are supposed to choose relevant topic for the Research Seminar (ARD402). The mentor for the same would be assigned in 7th Semester and its evaluation will be performed in 8th Semester. Students are encouraged to go for Research publication in reputed journal/conference

Eight Semester

Group	Paper Code	Paper Title	L	P	Credits
Practical/Viva-Voce					
DSC	ARD402	Research Seminar###(NUES)	-	-	4
DSC	ARD452/ ARD454	Major Project*** / Industry Internship####	-	-	16
					20

**** The student shall be allocated a supervisor/guide for project work at the start of the semester by the school/institute. The criteria for evaluation shall be the conceptualization of the project work, the background study/literature survey and the identification of objectives and methodology to be followed for the project. In the absence of the supervisor, the Dean/Director/Principal of the school/institute can assign the responsibility of the supervisor (for the purpose of examinations) to any faculty of the school/institute. The internal and external bifurcation of the project marks will be as per the bifurcation of marks for the practical examination.*

Students have the option to pursue his/her Dissertation on the basis of the Live Projects in a Recognized (CIN No. Required) Company/ Organization. The proposed company/ organization must be approved by the Dean/Director/Principal/APC.

SEMESTER WISE LIST OF MINOR SPECIALIZATION COURSE [MSC]

1. MSC shall be offered in various semesters as per the scheme of the program.
2. MSC shall be offered if at least 1/3rd of the total program strength opts for the course.
3. MSC subjects can be changed by APC in due course of time.

Category	Code	Paper Code	Course Name	L	P	Credits
MSC - I, II (Semester 5: choose any course)						
MSC-I	ARD371	ARD371T	Internet of Things Architecture and Protocols	3	-	3
		ARD371P	Internet of Things Architecture and Protocols Lab	-	2	1
	ARD373	ARD373T	Artificial Neural Network	3	-	3
		ARD373P	Artificial Neural Network Lab	-	2	1
	ARD375	ARD375T	Image Processing and Computer Vision	3	-	3
		ARD375P	Image Processing and Computer Vision Lab	-	2	1
MSC II	ARD377	ARD377T	Soft Computing	3	-	3
		ARD377P	Soft Computing Lab	-	2	1
	ARD379	ARD379T	Fundamentals of Robotics	3	-	3
		ARD379P	Robotics Lab	-	2	1
	ARD381	ARD381	Theory of Computation	4	-	4
MSC - III, IV (Semester 6 choose any course)						
MSC - III	ARD372	ARD372	Compiler Design	3	-	3
	ARD374	ARD374	Supply Chain Management	3	-	3
	ARD376	ARD376T	Decision Science and Analytics	2	-	2
		ARD376P	Decision Science and Analytics Lab	-	2	1
MSC - IV	ARD378	ARD378T	Edge AI	2	-	2
		ARD378P	Edge AI Lab	-	2	1
	ARD380	ARD380T	Web Technologies	2	-	2
		ARD380P	Web Technologies Lab	-	2	1

	ARD382	ARD382T	Metaverse and BlockChain	2	-	2
		ARD382P	Metaverse and BlockChain Lab	-	2	1
MSC - V, VI (Semester 7 choose any course)						
MSC - V	ARD471	ARD471T	Agentic Artificial Intelligence	2	-	2
		ARD471P	Agentic Artificial Intelligence Lab	-	2	1
	ARD473	ARD473T	Mobile Application Development	2	-	2
		ARD473P	Mobile Application Development Lab	-	2	1
MSC - VI	ARD475	ARD475T	Human Computer Interface	2	-	2
		ARD475P	Human Computer Interface Lab	-	2	1
	ARD477	ARD477T	Cryptography and Network Security	2	-	2
		ARD477P	Cryptography and Network Security Lab	-	2	1

SEMESTER WISE LIST OF VALUE ADDED COURSE [VAC]

Semester	Paper Code	Course Name	L	P	Credits
VAC (Semester 1,2,3)					
Semester 1	AR115	Human Values and Ethics	2	-	2
Semester 2	AR166	Analytics and Dashboard Development Lab	-	4	2
Semester 3	ARD213	Optimization Techniques	2	-	2

SEMESTER WISE LIST OF SKILL ENHANCEMENT COURSE[SEC]

Semester	Paper Code	Course Name	L	P	Credits
SEC (Semester 1,2,3)					
Semester 1	AR103	Programming for Problem Solving using C	3	-	3
	AR151	Programming for Problem Solving using C Lab	-	2	1
Semester 2	AR118	Analog Electronics	3	-	3

Semester 2	AR164	Electronics Lab/Workshop	-	2	1
Semester 3	ARD209	Object Oriented Programming using Java	3	-	3
	ARD257	Object Oriented Programming using Java Lab	-	2	1

SEMESTER WISE LIST OF ABILITY ENHANCEMENT COURSE[AEC]

Semester	Paper Code	Course Name	L	P	Credits
SEC (Semester 1,2,3)					
Semester 1	AR113	Design Thinking#(NUES)	1	-	1
Semester 1	AR157	Programming in Python Lab	-	2	1
Semester 2	AR120	Communication Skills	2	-	2
Semester 3	ARD211	Accountancy for Engineers	2	-	2

Important Notes:

1. a) The examinations, attendance criteria to appear in examinations, promotion and award of the degree shall be governed by the Ordinance 11 of the University.
   b) Grading System shall be as per Ordinance 11 of the University.
2. Minimum duration of the Bachelor of Technology programme and Bachelor of Technology part of the Bachelor / Master of Technology (Dual Degree) programme shall be 4 years (N=4 years) (8 semesters) for the students admitted in the first year/ first semester of the degree programme.
3. Lateral entry students shall be admitted in the second year / third semester of the degree programme (will be considered effectively in the batch admitted in the first year in the previous academic session and shall be deemed to have been exempted from the courses/papers of the first year of the degree programme). No exemption certificate shall be issued in any case. The minimum exit time/year for lateral-entry students shall be the same as for the batch in which he/she is admitted as a lateral-entry student in the second year.
4. Maximum duration of the Bachelor of Technology programme shall be 7 years (N+3 years). After completion of N+3 years of study, no extension shall be given to the student for completing the requirements of the degree and the admission of the student shall stand cancelled.
5. (a) To earn an Honours degree, the student may enrol for 20 credits or more (over and above the total offered credits in the classroom) through SWAYAM / NPTEL MOOCs platform only. The acquisition of the credits should be completed before the 15th of July of the graduating year.
   (b) Honours degree shall be awarded if and only if at least 20 credits are acquired through MOOCs. To obtain Honours in the programme, the student must apply for the same to the school/institute/college in the fifth semester by 30th August. The school/institute/college shall inform the list of such students to the Examination Division of the University.
   (c) The specific courses through MOOCs shall be registered by the student only after approval of a sub-committee of the Academic Programme Committee (APC) approved by the Dean/Director/Principal of the school/institute/college. The APC shall approve the course if it is not already studied by the student or the student shall not study it in future and adds value to the major area of specialization of the degree. The result of the approved papers shall be submitted by the student to the school/institute/college to be forwarded to the Examination Division of the University.
   (d) The cost of taking the MOOC course is to be borne by the concerned student. Such courses shall be reflected as additional courses/papers for the student.
   (e) The papers through MOOCs for the Honours Degree shall not be part of the curriculum considered for the computation of the student's SGPA/CGPA.
   (f) No Honours shall be conferred if the degree requirements are not completed within the minimum duration.
   (g) If a student has qualified any subject, which is a component of another online/offline degree program offered by any other university in India or abroad, it shall not be counted towards the award of Honours degree.
   (h) No Honours shall be conferred if the student fails in any of the papers offered to the student, at the time of verification for the award of the honours degree. That is, the Honours degree shall be conferred only to students with full credits of total offered credits.

(i) No Honours shall be conferred if the student has taken any of the interim degrees (as per MEME guidelines of University).

(j) The Honours degree shall only be awarded if the CGPA of the student is 7.5 and above. In addition, the student should be eligible for the award of the degree after the immediate completion of the fourth year of the course.

6. Multiple Entry Multiple Exit (MEME) Option is as per guidelines of University (refer notification number: F.34 (11)(13)/2025/DAA/1448 dated:24.03.2026).

7. Credit Summary:
   a. The students shall undergo the group of Courses / Papers (Refer Table 1) as enumerated in the scheme (For the students admitted in the First Year / First Semester)

Table 1: Distribution of Credits

Year	**1**		**2**		**3**		**4**		**Total Credits**
Semester	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	
DSC	7	7	7	13	12	16	14	20	96
MSC	4	4	4	4	8	6	6		36
MDC	3	3	3	3					12
AEC	2	2	2	2					8
SEC	4	4	4						12
VAC	2	2	2						6
SI					2		2		4
Total	22	22	22	22	22	22	22	20	**174****
	44		44		44		42		
Minimum Requirement	**40#**		**80##**		**120###**		**160***		

*Courses under AEC, VAC, and SI categories are compulsory. Research Seminar, Minor Project and Major Project are mandatory components of the programme whichever category/group they belong. NSS/NCC/DSW Clubs/Tech or Non-Tech Clubs/Societies of school/institute/college worth 2 credits to be earned over and above the minimum requirements.

For **B.Tech Honours, MOOCS of 20 credits are to be earned over and above the Total Credits offered.

Students intending to exit the programme after the completion of the first year as per MEME of university will obtain **Certificate in AIDS**, subject to earning 04 additional credits (over and above the minimum credit requirement prescribed) by doing domain-specific internship/ apprenticeship of minimum 8 weeks either in the University or in Industry that would help the candidates to acquire job-ready competencies required to enter the workforce.

Students intending to exit the programme after the completion of the second year as per MEME of university will obtain **Diploma in AIDS**, subject to earning 04 additional credits (over and above the minimum credit requirement prescribed) by doing domain-specific internship/ apprenticeship of minimum 8 weeks either in the University or in Industry that would help the candidates to acquire job-ready competencies required to enter the workforce. The student upon rejoining for third year may not require to apply for additional summer internship (if any such course requirement exists for fifth semester), his internship to meet exit condition as per prescribed guideline of MEME, may be considered for evaluation of such course.

Students intending to exit the programme after the completion of the third year as per MEME of university will get **Bachelor of Science (BSc) in AIDS,** subject to fulfillment of minimum requirement as prescribed in MEME of university.

b. The students admitted as Lateral Entry shall undergo Courses / Papers as enumerated in the scheme after third semester need to earn minimum 120* credits for completion of degree (i.e., first year is exempted from Table 1) and guidelines of MEME of University shall be followed for any interim degree. For B.Tech Honours, MOOCS of 20 credits are to be earned over and above the Total Credits offered.

8. Only after qualifying for the award of the degree of Bachelor of Technology, the student may be allowed to proceed to the Master in Technology part of the Bachelor / Master of Technology (Dual Degree)%.
9. The scheme and syllabi of the Master of Technology part of the Bachelor / Master of Technology (Dual Degree) is notified separately%.

NOTE: % Points 8 and 9 apply to USS-USAR only.

Autonomous Organizations (DAOs), Web 3.0 and Metaverse integration, governance, security and privacy issues in Web 3.0 and Metaverse.	
Unit III **Smart Contract and Consensus Algorithm:** Understanding Solidity Language; Creating a Smart Contract; Application of Smart Contract; Smart Contract; BOSCA: BlockChain Oriented Smart Contract Agreement; Blockchain Application Development using REMIX/SOLIDITY.	[5]
Unit IV **BLAST: BlockChain Algorithm for Secure Transaction.** Consensus Algorithms; conceptualization of Proof of Work and Proof of Stake. Concept of NFT (Non-Fungible Tokens), Merkle Tree Formation; **Case Study 1:** Design, develop and deployment of a smart contract on REMIX IDE. **Case Study 2:** Design a BlockChain to secure either: (a) Credit Card/Debit Card Information Information or (b) Cryptocurrency information from an authentic Cryptocurrency Dataset.	[5]
Text Books **[T1]** Bashir, I. (2020). Mastering Blockchain: A deep dive into distributed ledgers, consensus protocols, smart contracts, DApps, cryptocurrencies, Ethereum, and more. Packt Publishing Ltd. **[T2]** Lantz, L., & Cawrey, D. (2020). Mastering blockchain. O'Reilly Media. **[Web link]** https://www.youtube.com/@RAHULJOHARI7/videos	
Reference Books **[R1]** Mahankali, S. (2019). Blockchain: The Untold Story: From birth of Internet to future of Blockchain. BPB Publications.	

DETAILED SYLLABUS FOR 7th SEMESTER

Paper Code : ARD401	L	P	Credit
Paper Title : Reinforcement Learning	3	0	3

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks: As per University norms

- ➢ There should be 9 questions in the end term examination question paper.
- ➢ Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions.
- ➢ Apart from Question No. 1, the rest of the paper shall consist of four units As per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit.
- ➢ The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- ➢ The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required.

Course Outcomes [Bloom's Knowledge Level (KL)]:
CO1: Understand the basics concepts of reinforcement learning and MDP [K1, K2]
CO2: Understand and apply planning by dynamic programming and model free prediction [K1,K2,K3]
CO3: understand deep and multi agent reinforcement learning. Analyze and implement Temporal-Difference learning algorithms [K1, K2]
CO4: Apply and analyze various reinforcement learning applications and case studies [K3,K4]

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11
CO1	3	3	3	2	3	-	-	-	-	-	2
CO2	3	3	3	3	3	-	-	1	-	-	2
CO3	3	3	3	3	3	-	1	1	2	-	3
CO4	3	3	3	3	3	3	1	1	2	-	3

Course Content	**No of Lectures**
Unit I **Introduction and Foundations of Reinforcement Learning:** Historical perspective of Reinforcement Learning (RL). Basics of RL: definition, Motivation, examples, terminology, notation, assumptions, and applications; Comparison with supervised and unsupervised learning; Elements of Reinforcement Learning – agent, environment, state, action, reward; Reward hypothesis. **Markov property**: Markov Decision Processes (MDPs): states, actions, transition probabilities, reward functions, discount factor; Return and value functions. Policies – deterministic and stochastic; State-value function and action-value function; Bellman expectation equations; Optimal value functions and optimal policies. Multi-arm Bandits, Contextual Bandits and MDP Extensions	[7]
Unit II **Planning by Dynamic Programming (DP):** Overview of Dynamic Programming for MDPs. Principle of optimality. Iterative policy evaluation, Value Iteration, policy improvement, policy iteration, value iteration, generalized policy iteration. Asynchronous DP. DP Extensions and Convergence using Contraction Mapping, Efficiency of DP. Limitations of Dynamic Programming. **Model-free Prediction**: Monte-Carlo (MC) Learning, Temporal-Difference (TD) Learning, TD-Lambda and Eligibility Traces, First-visit and every-visit Monte Carlo methods Model-free Control-On-Policy MC Control, On-Policy TD Learning and Off-Policy Learning Value Function Approximation: Incremental Methods and Batch Methods, Deep Q-Learning, Deep Q-Networks and Experience Replay **Policy Gradient Methods**: Finite-Difference, Monte-Carlo and Actor-Critic Methods	[9]

Comparison of Dynamic Programming and Monte Carlo methods; Bias–variance trade-off.	
Unit III **Temporal-Difference learning**: Introduction; TD(0) algorithm; Relationship between Monte Carlo and Temporal-Difference methods; TD prediction. **Control Algorithms**: SARSA; Q-learning Learning and their variants, Expected SARSA, Convergence properties. Markov reward process (MRP), Overview of TD (1) and TD (λ). **Function Approximation**: Need for function approximation; Linear function approximation; Gradient-descent methods; On-policy vs off-policy approximation issues; Stability and divergence problems. **Hierarchical Reinforcement Learning**: Semi-Markov Decision Process, Learning with Options, Abstract Machines and MAXQ Decomposition. **Deep Reinforcement Learning**: PPO, DDPG, Double Q-Learning, Advanced Policy Gradients etc. **Multi-Agent Reinforcement Learning**: Cooperative vs. Competitive Settings, Mixed Setting, Games, MARL Algorithms.	[9]
Unit IV **Integrating Planning with Learning**: Model-based Reinforcement Learning, Integrated Architecture and Simulation-based Search. **Integrating AI Search and Learning**: Classical Games, Combining Minimax Search. **Reinforcement Learning applications and case Studies:** TD-Gammon, Samuel's Checkers Player, Watson's Daily-Double Wagering, Optimizing Memory Control, Human-Level Video game play, Mastering the game of Go, Personalized Web Services, Thermal Soaring, Robotics and Control, Recommendation Systems, Autonomous Systems.	[7]
Text Books **[T1]** Sutton, R. S., & Barto, A. G. (1998). Reinforcement learning: An introduction (Vol. 1, No. 1, pp. 9-11). Cambridge: MIT press. **[T2]** Szepesvári, C. (2022). Algorithms for reinforcement learning. Springer nature.	
Reference Books **[R1]** Bertsekas, D. (2019). Reinforcement learning and optimal control (Vol. 1). Athena Scientific. **[R2]** Kaelbling, L. P., Littman, M. L., & Moore, A. W. (1996). Reinforcement learning: A survey. Journal of Artificial Intelligence Research, 4, 237–285.	

Paper Code : ARD403	L	P	Credit
Paper Title : Recommender System	3	0	3

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks : As per University norms

- ➢ There should be 9 questions in the end term examination question paper.
- ➢ Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions.
- ➢ Apart from Question No. 1, the rest of the paper shall consist of four units As per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit.
- ➢ The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- ➢ The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required.

Course Outcomes [Bloom's Knowledge Level (KL)]:
CO1: Understand the concepts, challenges, and major recommendation approaches in recommender systems, including collaborative, content-based, knowledge-based, and hybrid methods. [K2]
CO2: Evaluate recommender systems using suitable metrics, explanation methods, and context-, time-, and location-aware recommendation techniques. [K4]
CO3: Analyze structural, social, and trust-centric recommender systems for ranking, link prediction, and recommendation in social networks. [K4]
CO4: Examine advanced recommender system techniques including attack-resistant methods, learning to rank, bandit algorithms, group recommendation, multicriteria recommendation, and privacy issues. [K4]

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11
CO1	3	1	1	1	1	-	-	-	-	-	3
CO2	3	2	2	1	1	-	-	-	-	-	3
CO3	3	2	3	2	2	-	-	-	-	-	2
CO4	2	2	3	1	1	-	-	-	-	-	2

Course Content	**No of Lectures**
Unit I **Introduction to Recommender Systems (RS):** Goals of RS, Basic models of RS, Challenges in RS. Collaborative filtering: Key properties of rating matrices, user and item based nearest recommendation, predicting ratings, neighborhood-based methods (clustering, dimensionality reduction, regression modelling and graph models), Model based collaborative filtering, Content-based, knowledge based, ensemble based and hybrid recommender system.	[8]
Unit II **Evaluating Recommender Systems:** Explanations in recommender systems, General properties of evaluation research, popular evaluation designs, goals of evaluation design design issues in offline recommender evaluation, accuracy metrics in offline evaluation. Context, time and location sensitive RS: Multidimensional approach, context prefiltering, post filtering, contextual modeling, temporal collaborative filtering, discrete temporal models, location aware recommender systems.	[8]

Unit III **Structural recommendations in networks:** Ranking algorithms, recommendations by collective classification, recommending friends: link prediction, social influence analysis and viral marketing. Social and trust centric RS: Multidimensional models for social context, network centric and trust centric methods, user interaction in social recommenders.	[8]
Unit IV **Attack-resistant RS**: Trade-offs Attack models, Types of attacks, detecting attacks on RS, strategies for robust RS, Online consumer decision making Learning to rank, multi-armed bandit algorithms, group RS, multi criteria RS, Active learning in RS, privacy in RS, Recommender systems and the next generation web.	[8]
Text Books **[T1]** Jannach, D., Zanker, M., Felfernig, A., & Friedrich, G. (2010). Recommender systems: an introduction. Cambridge university press. **[T2]** Aggarwal, C. C. (2016). Recommender systems (Vol. 1, No. 1). Cham: Springer International Publishing.	
Reference Books **[R1]** Ricci, F., Rokach, L., & Shapira, B. (2011). Introduction to Recommender Systems Handbook. Springer, Boston, MA. **[R2]** Manouselis, N., Drachsler, H., Verbert, K., & Duval, E. (2012). Recommender systems for learning. Springer Science & Business Media.	

Paper Code : ARD405	L	P	Credit
Paper Title : Cloud Dew Edge Fog (CDEF) Computing	3	0	3

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks : As per University norms

- There should be 9 questions in the end term examination question paper.
- Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions.
- Apart from Question No. 1, the rest of the paper shall consist of four units As per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit.
- The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required.

Course Outcomes [Bloom's Knowledge Level (KL)]:
CO1: Understand the fundamentals of cloud computing, service models, and cloud paradigms. [K2]
CO2: Analyze virtualization, hypervisors, web services, and multi-tenancy in cloud environments. [K4]
CO3: Examine cloud security, privacy, QoS, and inter-cloud migration issues. [K4]
CO4: Apply CloudSim and iFogSim tools for cloud, IoT, and fog computing applications. [K3]

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11
CO1	3	2	1	1	2	-	-	1	1	-	2
CO2	2	3	2	1	3	-	-	1	1	-	2
CO3	2	3	2	1	3	-	-	1	2	-	3
CO4	1	1	1	1	2	-	-	1	2	-	3

Course Content	No of Lectures
Unit I **Foundations of Cloud Computing** Introduction to Cloud Computing, Definition, Characteristics, Components, Cloud Service provider, Software As a Service(SAAS), Platform As a Service(PAAS), Infrastructure as a Service(IAAS) and Others, Load balancing and Resource optimization. Dew Computing, Edge Computing and Fog Computing paradigms. Comparison among Cloud computing platforms: Amazon EC2, Platform as Service: Google App Engine, Microsoft Azure, Meghraj etc	[7]
Unit II **Virtualization and Hypervisor** Introduction to Cloud Technologies, Study of Hypervisors, SOAP Protocol, REST, Comparison of XML with HTML, REST and Webservices, Virtual machine technology, virtualization applications in enterprises, Pitfalls of virtualization, Multi-tenancy using cloud data stores. Laws of Cloudonomics.	[8]
Unit III **Cloud Security and Inter Cloud Migration Issues** Cloud security fundamentals, Attacks in Cloud Computing, Privacy and Security in cloud, Cloud computing security architecture, Issues in cloud computing, QoS Issues in Cloud. Inter Cloud Migration issues.	[9]

Unit IV **Free and Open Source Software: CloudSim and iFogSim** **Case Study 1:** Design, develop and deploy Cloud Oriented Programs with Data Centers, Brokers and Cloudlet using Free and Open Source Software such as : CloudSim. **Case Study 2:** Design, develop and deploy IoT and Fog Computing Programs with Sensors, and Actuators using Free and Open Source Software such as : iFogSim.	[8]
Text Books **[T1]** Sosinsky, B. (2010). Cloud computing bible. John Wiley & Sons. **[T2]** Rajkumar Buyya, J. B., & Goscinski, A. (2019). Cloud computing principles and paradigms. **[T3]** Jayaswal, K. (2014). Cloud Computing Black Book. John Wiley & Sons. **[Web Link]** https://www.youtube.com/@RAHULJOHARI7/videos	
Reference Books **[R1]** Velte, A. T., Velte, T. J., Elsenpeter, R. C., & Elsenpeter, R. C. (2010). Cloud computing: a practical approach. **[R2]** Blokdyk, G. (2019). IBM Cloud Computing a Complete Guide.	

Paper Code : ARD471T	L	P	Credit
Paper Title : Agentic Artificial Intelligence	2	0	2

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks : As per University norms

- There should be 9 questions in the end term examination question paper.
- Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions.
- Apart from Question No. 1, the rest of the paper shall consist of four units As per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit.
- The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required.

Course Outcomes [Bloom's Knowledge Level (KL)]:
CO1: Explain the concepts, architectures, and design patterns of agentic artificial intelligence systems. [K2]
CO2: Apply LangGraph concepts to design AI agents with state management and memory. [K3]
CO3: Analyze Agentic RAG and multi-agent workflows for intelligent information retrieval and collaboration. [K4]
CO4: Identify deployment, monitoring, and ethical considerations in real-world agentic AI systems. [K2]

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11
CO1	3	2	0	1	2	-	-	1	1	-	2
CO2	2	3	2	1	3	-	-	1	1	-	2
CO3	2	3	2	1	3	-	-	1	2	-	3
CO4	1	0	0	1	2	3	3	1	2	-	3

Course Content	No of Lectures
Unit I **Foundations of Agentic AI and Design Patterns** Introduction to Agentic Artificial Intelligence, characteristics of intelligent agents, autonomous agents and human-in-the-loop systems, single-agent and multi-agent architectures, components of agentic systems: perception, reasoning, action, learning and memory, overview of agentic AI frameworks, design considerations and best practices, agentic design patterns: reflection, tool use, planning, ReAct and multi-agent collaboration.	[5]
Unit II **Building Agents with LangGraph** Introduction to LangGraph, agent workflows and state management, message trimming and filtering, short-term and long-term memory, external memory and memory schemas, integrating tools and APIs, deployment concepts in LangGraph, use cases of LangGraph-based agents.	[5]
Unit III **Agentic RAG and Multi-Agent Systems** Traditional RAG vs Agentic RAG, architecture and components of Agentic RAG, adaptive retrieval mechanisms, variants and applications of Agentic RAG, introduction to LlamaIndex for Agentic RAG, multi-agent systems concepts, coordination and collaboration among agents, workflow design for multi-agent systems.	[5]

Unit IV **Agent Development, Deployment and Observability** Introduction to AutoGen, roles and conversation patterns, developing collaborative AI agents, deploying agentic systems, monitoring and evaluation of AI agents, observability and AgentOps concepts, Introduction to LangSmith for agent monitoring, ethical issues in agentic AI: autonomy, bias, accountability, safety and responsible AI practices.	[5]
Text Books **[T1]** Biswas, A., & Talukdar, W. (2025). Building Agentic AI Systems: Create intelligent, autonomous AI agents that can reason, plan, and adapt. Packt Publishing Ltd. **[T2]** Gale, E. (2025). Mastering AI Agents: From Design to Deployment of Autonomous Systems. ISBN-13: 979-8307403822	
Reference Books **[R1]** Padgham, L., & Winikoff, M. (2005). Developing intelligent agent systems: A practical guide. John Wiley & Sons.	

Paper Code : ARD473T	L	P	Credit
Paper Title : Mobile Application Development	2	0	2

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks : As per University norms

- ➢ There should be 9 questions in the end term examination question paper.
- ➢ Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions.
- ➢ Apart from Question No. 1, the rest of the paper shall consist of four units As per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit.
- ➢ The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- ➢ The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required.

Course Outcomes [Bloom's Knowledge Level (KL)]:
CO1: Understand mobile computing, mobile platforms, UI/UX, security, and deployment concepts. [K2, K3]
CO2: Apply native mobile application development using Android and iOS tools, components, and programming languages. [K3, K4]
CO3: Develop cross-platform mobile applications using Flutter and React Native with storage and API integration. [K3, K4]
CO4: Analyze backend integration, testing, deployment, security, and maintenance of mobile applications. [K4, K5]

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11
CO1	3	2	1	-	1	-	-	-	-	-	2
CO2	3	3	3	2	3	-	-	1	2	-	2
CO3	3	2	3	3	3	-	-	2	2	-	3
CO4	2	3	2	3	2	-	2	1	3	-	2

Course Content	**No of Lectures**
Unit I **Introduction to Mobile Application Development** Introduction to mobile computing and mobile application development. Mobile device architecture, mobile operating systems, Android and iOS ecosystems, application lifecycle, native, hybrid and cross-platform applications. Mobile UI/UX principles, development environments, mobile security, privacy, performance considerations, application deployment, and app marketplaces.	[5]
Unit II **Native Mobile Application Development** Android architecture, Android application components, activities, intents, services, user interface development, data storage, notifications, location services, sensors, Android Studio environment, Java and Kotlin programming for Android applications. iOS architecture, application lifecycle, view controllers, user interface development, data persistence, notifications, device services, Xcode environment, Objective-C and Swift programming for iOS applications. Development of basic native mobile applications.	[5]

Unit III **Cross-Platform Mobile Application Development** Flutter and Dart fundamentals, widgets, layouts, navigation, state management, local storage, API integration and Firebase services. React Native architecture, JavaScript/TypeScript fundamentals, components, styling, navigation, hooks, state management, local storage, API integration and device integration. Development of cross-platform mobile applications using Flutter and React Native.	[5]
Unit IV **Mobile Backend, Testing And Deployment** RESTful APIs, cloud integration, authentication, notifications, location-based services, sensors and Firebase integration. Mobile application testing, debugging, performance optimization, mobile security, application permissions, secure data storage, mobile malware, rooting and jailbreaking concepts, version control, application packaging, signing, versioning, CI/CD concepts, deployment and publishing on Google Play Store and Apple App Store, privacy policies, end-user license agreements (EULA), app store compliance requirements, maintenance and emerging trends in mobile application development.	[5]

Text Books

[T1] Griffiths, D., & Griffiths, D. (2024). Head first Android development (3rd ed.). O'Reilly Media.
[T2] Ray, W. (2024). iOS apprentice: Beginning iOS development with Swift. Kodeco.
[T3] Osmani, A. (2023). Learning Flutter: Building multiplatform apps with Dart, Flutter, and Firebase (2nd ed.). O'Reilly Media.
[T4] Dabit, N. (2019). React Native in action. Manning Publications.

Reference Books

[R1] Phadke, A., & Kasam, M. (2022). Mobile application development. TechKnowledge Publications.
[R2] Phillips, B., Stewart, C., Hardy, B., & Marsicano, K. (2022). Android programming: The Big Nerd Ranch guide (5th ed.). Big Nerd Ranch.
[R3] Nahavandipoor, P. (2024). iOS 18 programming fundamentals with Swift: Swift, SwiftUI, and UIKit. O'Reilly Media.
[R4] Fling, B. (2009). Mobile design and development: Practical concepts and techniques for creating mobile sites and web apps. O'Reilly Media.

Paper Code : ARD475T	L	P	Credit
Paper Title : Human Computer Interface	2	0	2

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks : As per University norms

- ➢ There should be 9 questions in the end term examination question paper.
- ➢ Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions.
- ➢ Apart from Question No. 1, the rest of the paper shall consist of four units As per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit.
- ➢ The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- ➢ The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required.

Course Outcomes [Bloom's Knowledge Level (KL)]:
CO1: Recall the fundamental principles and historical milestones in the field of Human-Computer Interaction. (HCI) [K1]
CO2: Explain the key concepts of human factors and cognitive psychology and their relevance to HCI. [K2]
CO3: Apply user interface design guidelines, interaction design patterns and prototyping tools. [K3]
CO4: Analyze the effectiveness of different usability testing and evaluation methods in improving user experience and interface design. [K4]

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11
CO1	2	3	2	2	2	1	-	1	2	-	3
CO2	2	3	2	2	3	1	-	1	2	-	3
CO3	2	3	2	3	3	1	-	1	2	-	3
CO4	2	3	2	3	3	1	-	1	2	-	3

Course Content	**No of Lectures**
Unit I **Introduction to Human-Computer Interaction:** Fundamentals of human-computer interaction, Need for study of HCI, Historical overview of HCI, Human factors and cognitive psychology, User-centered design principles, Usability testing, Usability metrics and Evaluation methods.	[5]
Unit II **User Interface Design and Prototyping:** User interface design principles and guidelines, Visual design and information architecture, Interaction design patterns and techniques, Prototyping methods and tools, User feedback and iterative design process.	[5]
Unit III **User Experience and Evaluation:** User experience design principles, User research methods: interviews, surveys, and observations, Quantitative and qualitative data analysis, Accessibility and inclusive design considerations.	[5]
Unit IV **Advanced Topics in HCI:** Human-computer interaction in mobile and ubiquitous computing, Social computing and collaborative interfaces, Human-robot interaction, Ethical considerations in HCI, Future trends and emerging technologies in HCI.	[5]

Text Books

[T1] Norman, D. A. (2013). The design of everyday things (Revised and expanded ed.). Basic Books.
[T2] Rogers, Y., Sharp, H., Preece, J. (2023). Interaction Design: Beyond Human–Computer Interaction (6th Edition). John Wiley & Sons Inc.
[T3] Shneiderman, B., Plaisant C., Cohen, M., Jacobs, S. (2013). Designing the User Interface: Strategies for Effective Human-Computer Interaction (2013). Pearson Addison Wesley (5th Edition)

Reference Books

[R1] Benyon, D. (2013). Designing interactive systems: A comprehensive guide to HCI, UX and interaction design (2nd Edition.). Pearson Education.
[R2] Norman, D. A. (2004). Emotional design: Why we love (or hate) everyday things. Basic Books.

Paper Code : ARD477T	L	P	Credit
Paper Title : Cryptography and Network Security	2	0	2

Marking Scheme:
Teachers Continuous Evaluation: As per university examination norms from time to time.
End Term Theory Examination: As per university examination norms from time to time.

INSTRUCTIONS TO PAPER SETTERS: Maximum Marks : As per University norms

- ➢ There should be 9 questions in the end term examination question paper.
- ➢ Question No. 1 should be compulsory and cover the entire syllabus. This question should have objective or short answer type questions.
- ➢ Apart from Question No. 1, the rest of the paper shall consist of four units As per the syllabus. Every unit should have two questions. However, students may be asked to attempt only 1 question from each unit.
- ➢ The questions are to be framed keeping in view the learning outcomes of course/paper. The standard/ level of the questions to be asked should be at the level of the prescribed textbooks.
- ➢ The requirement of (scientific) calculators/ log-tables/ data-tables may be specified if required.

Course Outcomes [Bloom's Knowledge Level (KL)]:
CO1: To Understand the basic concepts of Cryptography. [K2]
CO2: To Analyze Social Cryptographic Techniques. [K2, K3]
CO3: To understand and analyze the working of the Symmetric Cryptography Algorithms and ASymmetric Cryptography Algorithms Smart Contracts. [K2, K4]
CO4: To understand and analyze the vulnerability and threats, active and passive Attacks. [K3,K4]

CO/PO	PO01	PO02	PO03	PO04	PO05	PO06	PO07	PO08	PO09	PO10	PO11
CO1	3	2	1	1	2	-	-	-	-	-	2
CO2	2	3	2	1	3	-	-	-	-	-	2
CO3	2	3	2	1	3	-	-	-	-	-	3
CO4	1	1	1	1	2	-	-	-	-	-	3

Course Content	**No of Lectures**
Unit I **Essence of Cryptography, Mathematics of Cryptography:** Modular Arithmetic and Congruence property, Symmetric and Asymmetric Cryptography, Classical Encryption techniques : Monoalphabetic and Polyalphabetic Cipher Technique: Caesar Cipher, Autokey Cipher, Vigenere Cipher, Rail Fence Cipher, Affine Cipher.	[5]
Unit II **Social Cryptographic Techniques:** Triplicative, Quadraplicative and Pentaplicative Cipher Technique. Cross Language Cipher Technique, Bi-Lingual Cross Language Cipher Technique. Evolution of Next Generation Cryptographic Techniques.	[5]
Unit III **Symmetric and Asymmetric Cryptography Fundamentals:** Confusion and Diffusion Property, Avalanche Effect, Key Management. **Symmetric Cryptography Algorithms:** Data Encryption Standard(DES), Advanced Encryption Standard(AES). **Asymmetric Cryptography Algorithms:** Diffie - Hellman key Exchange Algorithm and RSA(Rivest, Shamir and Adelman) Algorithm	[5]

Unit IV **Authentication, Intrusion Detection, and Web Security:** Intrusion detection System – Vulnerability and Threats, Active and Passive Attacks. Authentication Applications: Kerberos – X.509, Authentication Service, Electronic Mail Security, PGP, S/MIME – Penetration Testing - Web Security.	[5]
Text Books **[T1]** Stallings, W. (2017). Cryptography and network security, 7/E. Pearson Education India.. **[T2]** Forouzan, B. A. (2015). Cryptography & network security. McGraw-Hill, Inc..	
Reference Books **[R1]** Perlman, R., Kaufman, C., & Speciner, M. (2016). Network security: Private communication in a public world. Pearson Education India. **[R2]** Yung, M. (2010). Applied Cryptography and Network Security. Springer-Verlag Berlin Heidelberg.	