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.

DETAILED SYLLABUS FOR 5th SEMESTER

Paper Code :ARD301	L	P	Credit
Paper Title : Data Warehouse and Data Lakes	4	0	4

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: Ability of students to explain the concepts of Data Warehouses, Data Lakes, OLAP, and decision-support systems. [K1,K2]
CO2: Ability of students to apply Microsoft Azure data engineering services to create data pipelines in cloud environments. [K3]
CO3: Ability of students to analyze and implement Delta Lake, including data curation, and Silver Layer data processing in a lakehouse architecture. . [K4]
CO4: Ability of students to design and evaluate data aggregation pipelines, deployment strategies, and infrastructure solutions to address real-world data engineering challenges. [K4, K5]

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

Course Content	No of Lectures
Unit I **Data Warehousing and Business Analysis:** Data warehousing Components, Building a Data warehouse, Data Warehouse Architecture, DWH Schemas for Decision Support, Data Extraction-Cleaning-Transformation Tools, Metadata, Reporting, Query tools and Applications, Online Analytical Processing (OLAP), OLAP and Multidimensional Data Analysis, OLAP vs OLTP. **Discovering Storage and Compute Data Lakes:** Introducing data lakes, Discovering data lake architectures, Data Warehouse Vs Datalakes.	[10]

Unit II **Data Engineering on Microsoft Azure:** Introducing data engineering in Azure, Performing data engineering in Microsoft Azure-Self-managed data, engineering services (IaaS), Azure-managed data engineering services (PaaS), Data processing services in Microsoft Azure, Data engineering as a service (SaaS), Data cataloging and sharing services in Microsoft Azure; Opening a free account with Microsoft Azure **Understanding Data Pipelines:** Exploring data pipelines, Process of creating a data pipeline, Running a data pipeline, Sample lakehouse project **Data Collection Stage – The Bronze Layer:** Case Study, Architecting the Electronic data lake, Understanding the bronze layer, Configuring data sources, Configuring data destinations, Building the ingestion pipelines.	[12]
Unit III **Understanding Delta Lake:** Understanding how Delta Lake enables the lakehouse, Understanding Delta Lake, Creating a Delta Lake table, Changing data in an existing Delta Lake table, Performing time travel, Performing upserts of data, Understanding isolation levels, Understanding concurrency control, Cleaning up Azure resources **Data Curation Stage – The Silver Layer:** The need for curating raw data, The process of curating raw data, Developing a data curation pipeline, Running the pipeline for the silver layer, Verifying curated data in the silver layer	[10]
Unit IV **Data Aggregation Stage – The Gold Layer:** The need to aggregate data, The process of aggregating data, Developing a data aggregation pipeline, Running the aggregation pipeline, Understanding data consumption, Verifying aggregated data in the gold layer, Meeting customer expectations. Data Engineering Challenges and Effective Deployment Strategies, governance, Infrastructure Provisioning.	[10]
Text Books: **[T1]** Ponniah, P. (2004). Data warehousing fundamentals: A comprehensive guide for IT professionals. John Wiley & Sons. **[T2]** Kukreja, M. (2021). Data engineering with Apache Spark, Delta Lake, and Lakehouse. Packt Publishing. **[T3]** Haines, S. (2022). Modern data engineering with Apache Spark: A hands-on guide for building mission-critical streaming applications. Apress.	
Reference Books **[R1]** Han, J., Kamber, M., & Pei, J. (2006). Data mining: Concepts and techniques. Morgan Kaufmann. **[R2]** Lee, D., Wentling, T., Haines, S., & Babu, P. (2024). Delta Lake: The definitive guide: Modern data lakehouse architectures with data lakes. O'Reilly Media. **[R3]** Berson, A., & Smith, S. J. (2016). Data warehousing, data mining, & OLAP. Tata McGraw-Hill. **[R4]** Soman, K. P., Diwakar, S., & Ajay, V. (2006). Insight into data mining: Theory and practice. Prentice Hall of India.	

Paper Code : ARD303	L	P	Credit
Paper Title : Data Visualization	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: Ability of students to visualize the data objects in multiple dimensions. [K1,K2]
CO2: Ability of students to design and process the data for virtualization. [K3,K6]
CO3: Ability of students to apply the visualization techniques in physical sciences, computer science, applied mathematics and medical science. [K2,K3]
CO4: Ability of students to use data interaction techniques.[K2,K3]

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

Course Content	**No of Lectures**
Unit I **Introduction and Data Foundation Basics:** Relationship between Visualization and Other Fields, The Visualization Process, Pseudo code Conventions,The Scatter plot. Data Foundation, Types of Data, Structure within and between Records, Data Preprocessing, Data Sets.	[7]
Unit II **Foundations for Visualization:** Visualization stages, Semiology of Graphical Symbols, The Eight Visual Variables, Historical Perspective, Taxonomies, Experimental Semiotics based on Perception Gibson's Affordance theory – A Model of Perceptual Processing.	[9]
Unit III **Visualization Techniques:** **Spatial Data**: One-Dimensional Data, Two-Dimensional Data, Three-Dimensional Data, Dynamic Data, Combining Techniques. **Geospatial Data:** Visualization of Spatial Data, Point Data, Line Data, Area Data. Other Issues in Geospatial Data Visualization. **Multivariate Data:** Point,Based Techniques, Line, Based Techniques, Region,Based Techniques, Combinations of Techniques – Trees Displaying Hierarchical Structures –Graphics and Networks, Displaying Arbitrary Graphs/Networks.	[8]

Unit IV **Interaction Concepts and Techniques:** Text and Document Visualization: Introduction, Levels of Text Representations, The Vector Space Model,Single Document Visualizations, Document Collection Visualizations, **Extended Text Visualizations Interaction Concepts**: Interaction Operators, Interaction Operands and Spaces, A Unified Framework. **Interaction Techniques**: Screen Space, Object,Space,Data Space,Attribute Space, Data Structure Space, Visualization Structure, Animating Transformations,Interaction Control.	[8]
Text Books **[T1]** Ward, M. O., Grinstein, G., & Keim, D. (2010). Interactive data visualization: foundations, techniques, and applications. AK Peters/CRC Press. **[T2]** Ware, C. (2019). Information visualization: perception for design. Morgan Kaufmann.	
Reference Books **[R1]** Ehrenstrasser, L. (2009). Robert spence. information visualization design for interaction. Information Design Journal, 17(3), 279-280.	

Paper Code : ARD305	L	P	Credit
Paper Title : Containerized Data Processing Pipelines	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: Ability of students to understand the concepts of ETL, data pipelines, data sources, data quality, data cleaning, schema enforcement and target data architectures. [K1, K2]
CO2: Ability of students to build and containerize Python-based ETL applications using Docker images, Dockerfiles, volumes, networking and Docker Compose. [K2, K3]
CO3: Ability of students to deploy, scale and manage containerized data pipeline components on Kubernetes using Pods, Services, Deployments, StatefulSets, PVCs, ConfigMaps and Secrets. [K2, K3, K4]
CO4: Ability of students to design and implement distributed, automated and cloud-native data pipelines using Apache Spark/PySpark, Airflow, Kafka and MLOps workflow tools such as Kubeflow or Argo Workflows. [K3, K4, K5]

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

Course Content	No of Lectures
Unit I **Core ETL & Data Pipeline Concepts:** Meaning and need of ETL/ELT pipelines; batch, real-time and hybrid pipelines; data sourcing from relational databases (OLTP), NoSQL stores, APIs, logs, flat files and unstructured formats; data extraction patterns; data profiling, data cleaning, de-duplication, filtering, schema enforcement, data type casting, enrichment and structural reshaping; data validation, lineage, data quality and integrity checks; loading strategies for Data Warehouses (OLAP)	[7]
Unit II **Docker & Containerization Foundations:** Container versus Virtual Machine architecture; Docker images, containers, layers, tags and registries; containerizing Python ETL scripts using Pandas/PySpark; writing Dockerfiles and multi-stage Dockerfiles; dependency management and reproducible environments; minimizing image size and improving build cache; Docker volumes, bind mounts and persistent/temporary data handling; Docker networking and inter-container communication.	[9]

Unit III **Kubernetes (K8s) Cluster Orchestration:** Kubernetes architecture and components; nodes, control plane, Pods, ReplicaSets, Deployments, Services, namespaces, labels and selectors; deploying containerized ETL jobs and microservices; rolling updates and rollbacks; resource requests, limits and basic scheduling; StatefulSets for databases and stateful pipeline services; PersistentVolumes and PersistentVolumeClaims (PVC) for storage; ConfigMaps and Secrets for managing ETL configurations, API keys and credentials securely.	[9]
Unit IV **Distributed Processing, Workflow Automation and MLOps:** Distributed data processing using Apache Spark/PySpark or Dask running locally and on Kubernetes; designing scalable batch ETL jobs; real-time pipelines using Apache Kafka/Redpanda - topics, partitions, producers, consumers and stream ingestion on Kubernetes;, Jenkins or GitLab CI; deploying machine learning models as scalable microservices.	[7]
Text Books **[T1]** Kleppmann, M. (2017). Designing Data-Intensive Applications. O'Reilly Media. **[T2]** Mouat, A. (2015). Using Docker: Developing and Deploying Software with Containers. O'Reilly Media. **[T3]** Luksa, M. (2017). Kubernetes in Action. Manning Publications. **[T4]** Chambers, B., & Zaharia, M. (2018). Spark: The Definitive Guide. O'Reilly Media.	
Reference Books **[R1]** Hightower, K., Burns, B., & Beda, J. (2017). Kubernetes: Up and Running. O'Reilly Media. **[R2]** Kimball, R., & Ross, M. (2013). The Data Warehouse Toolkit: The Definitive Guide to Dimensional Modeling. Wiley. **[R3]** Basiri, A., Behnam, N., de Rooij, R., et al. (2016). Chaos Engineering. O'Reilly Media. **[R4]** Apache Airflow Documentation, Apache Kafka Documentation, Apache Spark Documentation, Docker Documentation and Kubernetes Documentation.	

Paper Code : ARD371T	L	P	Credit
Paper Title :Internet of Things Architecture and Protocol	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: To understand the ecosystem and hardware peripherals of the Industrial Internet of Things (IIoT). [K1, K2]

CO2: To understand and implement industrial communication protocols at the network and application layer. [K3]

CO3: To analyze core architecture, reference models, cloud platforms and develop basic predictive maintenance frameworks. [K4]

CO4: To evaluate cybersecurity risks and apply functional safety standards (IEC 61508/62443) to automation networks. [K4, K5]

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

Course Content	**No of Lectures**
Unit I **IoT Fundamentals and System Programming:** IoT Ecosystem and Core components: smart sensors, actuators, edge gateways, and industrial cloud infrastructure, Evolution from M2M, Edge computing vs. cloud computing paradigms, data ingestion pipelines, and processing topologies, IoT and M2M value chain. Introduction to programming using Embedded C/C++ and hardware system design utilizing Arduino/Raspberry Pi, and ESP32/ESP8266 platforms with emphasis on sensor interfacing, output regulation, and pin-level input processing.	[7]
Unit II **IoT Communication Protocols:** Modern Industrial Ethernet standards: Profinet, EtherCAT, Modbus TCP. Digital sensor communication, IEEE802.15.4–BACNet Protocol, KNX, ZigBee protocol architecture. IoT network layer protocol: 6LoWPAN (IPv6 over Low-Power Wireless Personal Area Networks), Threads, RPL (Routing Protocol for Low-Power and Lossy Networks), Cellular IoT Extensions (NB-IoT & LTE-M). IoT application layer protocols: HTTP, MQTT (Message Queuing Telemetry Transport), CoAP (Constrained Application Protocol), AMQP	[9]

Unit III **IoT Architecture and Cloud Platforms:** IoT Open-source architecture (OIC) & Design principles, Interoperability and standardization using OPC UA. Industrial Internet Reference Architecture (IIRA), RAMI 4.0. IoT Prototyping Frameworks: Android Things, ThingSpeak: cloud-based data storage and analytics platform, IoTivity: An Open source IoT stack Overview, Resource modelling with Supported Operational Methods (CRUDN) and Abstraction, Node-RED: Visual Architecture (Flow-Based Programming). IoT cloud platforms: AWS IoT Core, Microsoft Azure IoT and Blynk IoT Platform.	[8]
Unit IV **Web of Things and Functional Safety:** Architecture Standardization and Platform Middleware for WoT, Unified Multitier WoT Architecture, REST (Representational State Transfer), WoT Portals and Business Intelligence. Cybersecurity vulnerabilities in IT-OT convergence, IoT Security Tomography, threat landscapes, common attack vectors, and defense-in-depth strategies. Industrial security standards: IEC 62443 overview. Functional safety in automated environments: introduction to IEC 61508 and IEC 61511. Safety Integrity Levels (SIL) assessment, risk matrix, fail-safe architectures, and emergency shutdown system integration.	[8]
Text Books **[T1]** Gilchrist, A. (2016). Industry 4.0: The Industrial Internet of Things. Apress. **[T2]** Misra, S., Roy, C., & Mukherjee, A. (2021). Introduction to industrial Internet of Things and Industry 4.0. CRC Press. **[T3]** Cirani, S., Ferrari, G., Picone, M., & Veltri, L. (2018). Internet of things: Architectures, protocols and standards. John Wiley & Sons..	
Reference Books **[R1]** Lea, P. (2018). IoT architecture and design handbook. Packt Publishing.	

Paper Code : ARD373T	L	P	Credit
Paper Title : Artificial Neural Network	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: Ability to create different neural networks of various architectures both feed forward and feed backward[K1,K2]
CO2: Ability to perform the training of neural networks using various learning rules[K1,K2,K3]
CO3: Ability to perform the testing of neural networks and do the performance analysis of the networks for various pattern recognition applications. [K2,K3,K4]
CO4: Ability to related artificial neural networks with real life problems[K4,K5]

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

Course Content	**No of Lectures**
Unit I **Introduction:** A Neural Network,Human Brain,Models of a Neuron,Neural Networks viewed as Directed Graphs, Network Architectures,Knowledge Representation,Artificial Intelligence and Neural Networks Learning Process: Error Correction Learning, Memory Based Learning, Hebbian Learning, Competitive, Boltzmann Learning, Credit Assignment Problem,Memory, Adaption, Statistical Nature of the Learning Process	[7]
Unit II **Single Layer Perceptrons:** Adaptive Filtering Problem,Unconstrained Organization Techniques, Linear Least Square Filters, Least Mean Square Algorithm, Learning Curves, Learning Rate,Annealing Techniques, Perceptron–Convergence Theorem, Relation Between Perceptron and Bayes Classifier for a Gaussian Environment. Multilayer Perceptron: Back Propagation Algorithm XOR Problem, Heuristics, Output Representation and Decision Rule,Computer Experiment,Feature Detection	[9]
Unit III **BackPropagation:** BackPropagation and Differentiation, Hessian Matrix,Generalization,Cross Validation,Network Pruning Techniques,Virtues and Limitations of BackPropagation Learning, Accelerated Convergence,Supervised Learning	[9]

Unit IV **Self-Organization Maps(SOM):** Two Basic Feature Mapping Models,Self-Organization Map, SOM Algorithm,Properties of Feature Map,Computer Simulations,Learning Vector Quantization, Adaptive Pattern Classification Neuro Dynamics: Dynamical Systems, Stability of Equilibrium States, Attractors, Neuro Dynamical Models, Manipulation of Attractors as a Recurrent Network Paradigm Hopfield Models–Hopfield Models,Computer Experiment.	[7]
Text Books **[T1]** Haykin, S. S. (2009). Neural networks and learning machines (3rd ed.). Pearson Education **[T2]** Aggarwal, C. C. (2023). Neural networks and deep learning: A textbook (2nd ed.). Springer International Publishing.	
Reference Books **[R1]** Fu, L. M. (2003). Neural networks in computer intelligence (1st ed.). McGraw-Hill Education	

Paper Code : ARD375T	L	P	Credit
Paper Title: Image Processing and Computer Vision	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: Be able to formulate the mathematical operations for image processing. [K1, K2]
CO2: Understand and apply the different filtering operations in the spatial domain. [K3, K4]
CO3: To Understand, apply and analyse image feature extraction and segmentation. [K2, K4]
CO4: To Understand and apply concepts of 3D, camera matrix and motion analysis. [K3, K4]

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

Course Content	No of Lectures
Unit I: Image Formation and Processing Introduction to Computer Vision, Photometric image formation, The digital camera, Geometric transformations, Image Enhancement: Point operators, neighborhood processing, Spatial filtering. Detection of Points, patches, Edge and Line, Canny edge detection.	[8]
Unit II: Interest Point, Region and Shape Representation Image interest point detection: interest points, aperture problem, Harries corner detection, Segmentation: Threshold based, Edge based and Region Based Segmentation, Boundary representation, Boundary Descriptors, Shape representation: Region based and contour based, Active contours (snakes).	[8]
Unit III: Image Understanding Image Understanding methods: bottom up and top down, Bottom-Up Approach: Image feature extraction (texture feature, SIFT, HOG), Machine learning/pattern recognition algorithms for object detection, object classification and segmentation. Top-down approach: Model based control, Active shape model, active appearance model, Point distribution models.	[8]
Unit IV: Camera Calibration and 3D Reconstruction Camera calibration, Camera parameter estimation, Triangulation, Two-frame structure from motion, Factorization, Parametric motion - Spline-based motion, Optical flow, Shape from X,	[8]

Active range finding, Surface representations, Point-based representations, Volumetric representations, Model-based reconstruction	

Text Books

[T1] Szeliski, R. (2022). Computer vision: algorithms and applications. Springer Nature.
[T2] Gonzalez, R. C. (2009). Digital image processing. Pearson education india.

Reference Books

[R1] Trucco, E., & Verri, A. (2010). Introductory techniques for 3-D computer vision (Vol. 201, pp. 10-5555). Englewood Cliffs: Prentice Hall.
[R2] Treiber, M. A. (2010). An introduction to object recognition: selected algorithms for a wide variety of applications. Springer Science & Business Media.

Paper Code : ARD377T	L	P	Credit
Paper Title : Soft 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: Ability to identify and describe soft computing techniques and their roles in building intelligent machines. [K1,K2]
CO2: Ability to apply fuzzy logic and reasoning to handle uncertainty and solve various engineering Problems. [K1,K2,K3]
CO3: Ability to apply genetic algorithms to combinatorial optimization problems. [K1,K2]
CO4: Ability to evaluate and compare solutions by various Evolutionary computing approaches for a given problem. [K1, K2,K3]

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

Course Content	No of Lectures
Unit I **Introduction to Soft Computing:** Evolution of Computing, Soft Computing Constituents, From Conventional AI to Computational Intelligence, Machine Learning Basics. **Fuzzy Mathematics:** Fuzzy Sets, Operations on Fuzzy Sets, Fuzzy Relations, Membership Functions, Fuzzy Rules and Fuzzy Reasoning, Fuzzy Decision Making.	[7]
Unit II **Fuzzy Inference Systems:** Method of fuzzification, method of defuzzification, design of fuzzy inference system, Expert Systems,knowledge based expert system, expert system applications, use cases.	[9]
Unit III **Introduction to Optimization:** Optimization, random variable, random walk,levy flight,meta heuristic concepts. **Genetic Algorithms**: Genetic algorithm: Fundamental, basic concepts, working principle, encoding, fitness function, reproduction, Genetic modeling: Inheritance operator, cross over, inversion & deletion, mutation operator, Bitwise operator, Generational Cycle, Convergence of GA, Applications & advances in GA, Differences & similarities between GA & other traditional methods.	[9]

Unit IV **Swarm Algorithms:** Introduction to Particle swarm optimization - PSO, operators - GA and PSO in engineering applications, Cuckoo Search, Firefly algorithm. **Optimization of Machine Learning using Metaheuristic:** ANN and metaheuristic, SVM and metaheuristic	[7]
Text Books **[T1]** Jang, J. S. R., Sun, C. T., & Mizutani, E. (2003), Neuro:Fuzzy and Soft Computing, Prentice: Hall of India. **[T2]** Sivanandam, S. N., & Deepa, S. N. (2007). Principles of soft computing (with CD). John Wiley & Sons.	
Reference Books **[R1]** Goldberg, D. E. (1989). Genetic algorithms: Search, optimization and machine learning. Addison-Wesley.	

Paper Code :ARD379T	L	P	Credit
Paper Title : Fundamentals of Robotics	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: Ability of students to understand the concepts of ETL, data pipelines, data sources, data quality, data cleaning, schema enforcement and target data architectures. [K1, K2]
CO2: Ability of students to build and containerize Python-based ETL applications using Docker images, Dockerfiles, volumes, networking and Docker Compose. [K2, K3]
CO3: Ability of students to deploy, scale and manage containerized data pipeline components on Kubernetes using Pods, Services, Deployments, StatefulSets, PVCs, ConfigMaps and Secrets. [K2, K3, K4]
CO4: Ability of students to design and implement distributed, automated and cloud-native data pipelines using Apache Spark/PySpark, Airflow, Kafka and MLOps workflow tools such as Kubeflow or Argo Workflows. [K3, K4, K5]

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

Course Content	No of Lectures
Unit I **Introduction:** Fundamentals of Robotics, Robot Kinematics: Position Analysis, Dynamic Analysis and Forces. Components of Robotic Systems such as Sensors, Actuators, Controllers, End-Effectors, and Power Systems; Degrees of Freedom (DOF), Robot Configurations, Workspace, and Performance Characteristics; Robot Programming Concepts; Applications of Robotics in Manufacturing, Healthcare, Agriculture, Logistics, Defense.	[7]
Unit II **Industrial Robots:** Robot Classification, including Industrial, Service, Mobile, Humanoid, and Collaborative Robots; medical robots, Robot Specification, kinematic representations and transformations, dynamics techniques; trajectory planning and control. **Robot Programming languages & systems:** Introduction, the three levels of robot programming, requirements of a robot programming language, problems peculiar to robot programming languages.	[9]

Unit III **Robotics and Its applications:** DDD concept, Intelligent robots, Robot anatomy-Definition, law of robotics, History and Terminology of Robotics-Accuracy and repeatability of Robotics-Simple problems-Specifications of Robot-Speed of Robot, Robot joints and links-Robot classifications Architecture of robotic systems-Robot Drive systems-Hydraulic, Pneumatic and Electric system	[9]
Unit IV **Introduction AI&ML in Robotics:** Supervised, Unsupervised, and Reinforcement Learning Techniques; Deep Learning for Robotic Perception and Decision-Making; Computer Vision and Natural Language Processing Applications in Robotics; Human–Robot Interaction and Collaborative Robotics; Cloud Robotics, Edge AI, and Digital Twin Technologies; Swarm Robotics and Multi-Agent Systems; Generative AI and Foundation Models for Robotics; Ethical, Safety, Security, and Future Trends in Intelligent Robotic Systems.	[7]

Text Books

[T1] Niku, S. B. (2020). Introduction to robotics: Analysis, control and applications (3rd ed.). Wiley.
[T2] Groover, M. P. (2020). Automation, production systems, and computer-integrated manufacturing (5th ed.). Pearson.
[T3] Kamal, R. (2024). Internet of Things: Architecture and design principles (3rd ed.). McGraw-Hill Education.
[T4] Gilchrist, A. (2025). Industry 4.0: The Industrial Internet of Things (2nd ed.). Apress.

Reference Books

[R1] Craig, J. J. (2018). Introduction to robotics: Mechanics and control (4th ed.). Pearson.
[R2] Siciliano, B., Sciavicco, L., Villani, L., & Oriolo, G. (2022). Robotics: Modelling, planning and control. Springer.
[R3] Lamb, F. (2021). Industrial automation: Hands-on (2nd ed.). McGraw-Hill Education.
[R4] Uckelmann, D., Harrison, M., & Michahelles, F. (2021). Architecting the Internet of Things. Springer.
[R5] Thrun, S., Burgard, W., & Fox, D. (2005). Probabilistic robotics. MIT Press.

Paper Code : ARD381	L	P	Credit
Paper Title : Theory of Computation	4	0	4

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 fundamentals of automata, formal languages, regular expressions, and finite automata, and analyze regular languages using closure properties and pumping lemma. [K1, K2]
CO2: Analyze context-free grammars and context-free languages, including normal forms, ambiguity, closure properties, and decision problems. [K2]
CO3: Apply Pushdown Automata and Turing Machine models to recognize languages and understand the equivalence between automata and grammars. [K2]
CO4: Analyze the limits of computation using undecidability and complexity theory concepts such as NP-completeness, NP-hardness, and polynomial-time reductions. [K3]

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

Course Content	**No of Lectures**
Unit I **Automata and Language Theory:** Chomsky Classification, Finite Automata, Moore and Mealy machines, Equivalence of Moore and Mealy machines, Deterministic Finite Automata (DFA), Non-Deterministic Finite Automata (NFA) and ε–NFA, Regular Expressions, Equivalence of DFAs, NFAs and Regular Expressions, Minimizing DFA, Closure properties of Regular grammar, Non-Regular Languages, Pumping Lemma for regular languages.	[10]
Unit II **Context Free Grammar (CFG): D**efinition, examples, derivations and derivation trees, ambiguity in grammars, inherent ambiguity, conversion of ambiguous grammar to unambiguous grammar (conceptual), useless symbols and simplification of CFGs.Normal Forms: Chomsky Normal Form (CNF) and Greibach Normal Form (GNF). **Context Free Languages (CFLs):** Closure properties, decision properties (emptiness, finiteness, membership), Pumping Lemma for Context Free Languages and its applications.	[12]

Unit III **Pushdown Automata (PDA):** Definition and description, instantaneous description, language accepted by PDA, acceptance by final state and empty stack, deterministic PDA, equivalence of PDA and CFG, construction of PDA from CFG and CFG from PDA, concept of two-stack PDA and its computational power. **Turing Machines (TM):** Basic model, definition and representation, instantaneous description, language acceptance by Turing Machine, variants of Turing Machine, Universal Turing Machine, Church's Thesis, Recursive and recursively enumerable language. .	[10]
Unit IV **Undecidability:** Introduction to undecidability, undecidable problems related to Turing Machines, Halting Problem, Post Correspondence Problem (PCP) and Modified PCP, brief introduction to recursive function theory. **Complexity Theory:** The class P as consensus class of tractable sets. Classes NP, co-NP, Polynomial time reductions. NP-completeness, NP-hardness.	[10]
Text Books **[T1]** Sipser, M. (2014). Introduction to the Theory of Computation. ACM Sigact News, 27(1), 27-29, 3rd Edition. **[T2]** Hopcroft, J. E., Motwani, R., & Ullman, J. D. (2008). Introduction to automata theory, languages, and computation. ACM Sigact News, 32(1), 60-65. **[T3]** Linz, P., & Rodger, S. H. (2022). An introduction to formal languages and automata. Jones & Bartlett Learning.	
Reference Books **[R1]** Mozgovoy, M. (2009). Algorithms, Languages, Automata, and Compilers: A Practical Approach: A Practical Approach. Jones & Bartlett Learning. **[R2]** Cohen, D. I. (1996). Introduction to computer theory. John Wiley & Sons. **[R3]** Martin, J. C. (1991). Introduction to Languages and the Theory of Computation (Vol. 4). NY: McGraw-Hill.	

DETAILED SYLLABUS FOR 6th SEMESTER

Paper Code : ARD302	L	P	Credit
Paper Title : MLOps and Model Deployment	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 MLOps fundamentals, machine learning lifecycle, data management, experiment tracking, and feature store concepts[K1, K2]
CO2: Apply MLOps pipelines for model development, training, evaluation, versioning, and lifecycle management[K2, K3]
CO3: Apply model deployment architectures, serving techniques, and deployment strategies for machine learning applications[K2, K3, K4]
CO4: Analyze deployed machine learning systems with respect to monitoring, performance optimization, security, governance, and ethical considerations[K4, K5]

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

Course Content	No of Lectures
Unit I **MLOps Foundations and Data Lifecycle:** Introduction to MLOps and its significance, challenges in managing machine learning systems in production, comparison of traditional software development, DevOps and MLOps, machine learning lifecycle from data to deployment readiness, key components of MLOps, MLOps workflows and tooling landscape. Data management for machine learning systems, data acquisition and preprocessing pipelines, data versioning concepts, reproducibility and experiment tracking, overview of DVC. Feature stores, motivation and role of feature stores in machine learning and generative AI applications, benefits of feature stores for MLOps, overview of Feast.	[7]
Unit II **MLOps Pipelines and Model Lifecycle Management:** Machine learning model development workflows, feature engineering pipelines, training and evaluation processes, comparison of development of small models and large models including large language models, hyperparameter tuning and optimization, experiment tracking and model lineage, overview of MLflow. Continuous integration practices for machine learning, version control for code, data and models, automated testing and validation of models, model versioning and model registry concepts, handling data drift and concept drift.	[9]

Unit III **Model Deployment Architectures and Serving:** Concept of model deployment, deployment architectures for machine learning systems, batch inference and real time inference, online and offline deployment modes, model serving patterns, REST API based model serving, containerization concepts, introduction to Docker for model deployment, orchestration overview, deployment strategies for cloud, edge and on premises environments.	[9]
Unit IV **Model Deployment Operations and Governance:** Operational aspects of deployed models, monitoring and logging of deployed machine learning systems, performance optimization and scaling strategies, model performance monitoring, detection of model drift and data drift, deployment strategies including blue green deployment, canary deployment and rollback mechanisms. Security considerations in model deployment, introduction to MLSecOps, governance and compliance, model explainability and ethical considerations, bias detection and tracking, deployment considerations for large language models, overview of advanced topics such as federated learning and edge inferencing.	[7]
Text Books **[T1]** Huyen, C. (2022). Designing machine learning systems. " O'Reilly Media, Inc.". **[T2]** Lakshmanan, V., Robinson, S., & Munn, M. (2020). Machine learning design patterns. O'Reilly Media.	
Reference Books **[R1]** Ameisen, E. (2020). Building machine learning powered applications: Going from idea to product. " O'Reilly Media, Inc.". **[R2]** Wilson, B. (2022). Machine learning engineering in action. Simon and Schuster. **[R3]** Chen, C., Murphy, N. R., & Srinivasan, K. (2023). Reliable machine learning. O'Reilly Media.. **[R4]** Kleppmann, M. (2017). Designing data-intensive applications: The big ideas behind reliable, scalable, and maintainable systems. " O'Reilly Media, Inc.".	

Paper Code : ARD304	L	P	Credit
Paper Title : Time Series Modeling and Forecasting	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: To understand fundamental concepts of time series data, including components such as trend, seasonality, and cyclic variations.[K1,K2]
CO2: To analyze and preprocess time series data using techniques like visualization, decomposition, and stationarity testing.
CO3: To develop and apply time series models such as AR, MA, ARMA, and ARIMA for analyzing and forecasting data.[K2,K3,K4]
CO4: To evaluate and interpret forecasting results using appropriate accuracy measures and apply them to real-world problems.[K5,K6]

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

Course Content	No of Lectures
Unit I **Introduction to Time Series:** Basic results of matrix algebra and regression analysis, decomposition into Various Components, free hand curve fitting method and semi-averages method for the determination of Secular Trend, mathematical curve fitting and moving averages for trend component, Seasonal plots, Simple Time Series or Run sequence plot, Seasonal plot, Seasonal subseries plot, Multiple box plots, Cyclical component and its graphical presentation, Methods for the Seasonal Component and Variate Difference Method for estimating variance of irregular variations, Effect of elimination of trend on other components.	[7]
Unit II **Time Series Processes:** Introduction to Time series processes and Stochastic process, Various descriptive measures, process mean and variance, ACVF and ACF, Partial autocorrelation function (PACF), Strongly and weekly Stationary processes, Ergodicity in time series, Deterministic, purely non-deterministic Processes. **Stationary Processes for Time Series Modelling:** Wold Decomposition, General Linear Process, its ACF and other properties, Moving Average Process and its properties, ACF, PACF, Autoregressive Process and	[9]

its properties, ACF, PACF, Yule-Walker equations, Mixed ARMA processes and their properties, mean, autocovariances, ACF, Stationarity and invertibility conditions for AR, MA and mixed ARMA processes.	
Unit III **Estimation of Parameters:** Estimation of parameters of autoregressive processes, Estimation of parameters of AR, MA and ARMA processes. Forecasting with Stationary Processes, Diagnostics Checking, Non-Stationary and Long Memory Processes.	[8]
Unit IV **Multivariate Time Series Analysis and Volatility Models:** Multivariate Time Series Processes, Stochastic Volatility Models: ARCH, GARCH Processes.	[8]
Text Books **[T1]** Box, G. E., Jenkins, G. M., Reinsel, G. C., & Ljung, G. M. (2015). Time series analysis: forecasting and control. John Wiley & Sons. **[T2]** Brockwell, P. J., & Davis, R. A. (2009). Time series: theory and methods. Springer science & business media.	
Reference Books **[R1]** Kirchgässner, G., Wolters, J., & Hassler, U. (2012). Introduction to modern time series analysis. Springer Science & Business Media. **[R2]** Chatfield, C., & Xing, H. (2019). The analysis of time series: an introduction with R. Chapman and hall/CRC.	

Paper Code : ARD306	L	P	Credit
Paper Title : Big Data Analytics	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: Ability of students to optimize business decisions and create competitive advantage with Big Data analytics. [K3, K6]
CO2: Ability of students to explore the fundamental concepts of big data analytics. [K1,K2,K3]
CO3: Ability of students to understand the applications using Map Reduce Concepts. [K1,K2]
CO4: Ability of students to understand programming tools PIG & HIVE in the Hadoop ecosystem. [K2,K4]

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

Course Content	No of Lectures
Unit I **Introduction to Big Data:** Introduction to Big Data Platform, Challenges of Conventional Systems-Intelligent data analysis,Nature of Data-Analytic Processes and Tools-Analysis vs Reporting	[7]
Unit II **Mining Data Streams:** Introduction To Streams Concepts, Stream Data Model and Architecture-Stream Computing-Sampling Data in a Stream, Filtering Streams, Counting Distinct Elements in a Stream, Estimating Moments, Counting Oneness in a Window, Decaying Window-Real time Analytics Platform (RTAP) Applications, Case Studies - Real Time Sentiment Analysis-Stock Market Predictions	[9]
Unit III **Hadoop:** History of Hadoop- the Hadoop, Distributed File System – Components of Hadoop, Analysing the Data with Hadoop, Scaling Out, Hadoop Streaming, Design of HDFS, Java interfaces to HDFS Basics, Developing a Map Reduce Application, How MapReduce Works, Anatomy of a MapReduce Job run-Failures, Job Scheduling-Shuffle and Sort, Task execution-Map Reduce Types and Formats, Map Reduce Features Hadoop environment	[8]

Unit IV **Frameworks:** Applications on Big Data Using Pig and Hive, Data processing operators in Pig, Hive services, Hive QL, Querying Data in Hive, Fundamentals of HBase and ZooKeeper, IBM InfoSphere Big Insights and Streams. **Predictive Analytics**: Simple linear regression, Multiple linear regression Interpretation of regression coefficients.Visualizations, Visual data analysis techniques interaction techniques-Systems and applications.	[8]
Text Books **[T1]** White, T. (2012). Hadoop: The definitive guide. " O'Reilly Media, Inc."**.** **[T2]** Zikopoulos, P., & Eaton, C. (2011). Understanding big data: Analytics for enterprise class hadoop and streaming data. McGraw-Hill Osborne Media. **[T3]** Bahga, A. (2019). Big Data analytics: A hands-on approach.	
Reference Books **[R1]** Baesens, B. (2014). Analytics in a big data world: The essential guide to data science and its applications. John Wiley & Sons.	

Paper Code : ARD308	L	P	Credit
Paper Title : Deep 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: Ability of students to understand the basics concepts of Deep feed forward networks. [K1, K2]
CO2: Ability of students to understand and apply convolution networks and adversarial networks. [K1,K2,K3]
CO3: Ability of students to understand and apply recurrent and recursive nets for sequential data. [K1,K2,K3]
CO4: Ability of students to apply and analyse various deep learning applications with case studies. [K3,K4]

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

Course Content	**No of Lectures**
Unit I **Deep Feedforward Networks:** Artificial Neural Networks, Artificial Neuron, Example: Learning XOR, Gradient-Based Learning, Hidden Units, Architecture Design, Back-Propagation and Other Differentiation Algorithms, Regularization for Deep Learning- Parameter Norm Penalties, Dataset Augmentation, Noise Robustness, Early Stopping, Dropout, Adversarial Training, Optimization for Training Deep Models- How Learning Differs from Pure Optimization? Challenges in Neural Network Optimization, Basic Algorithms- Stochastic Gradient Descent, momentum. Parameter Initialization Strategies, Algorithms with Adaptive Learning Rates, Optimization Strategies and Meta-Algorithms.	[8]
Unit II **Convolutional Networks:** The Convolution Operation, Motivation, Pooling, Data Types, building block of CNN, Transfer Learning, Autoencoders- Under Complete, regularized, sparse Denoising, Generative Modeling with DL, Generative Adversarial Network Revisiting Gradient Descent, Momentum Optimizer, RMSProp, Adam	[8]
Unit III **Recurrent and Recursive Nets:** Sequential data, Unfolding Computational Graphs, Recurrent Neural Networks, Bidirectional RNNs, Deep Recurrent Networks, Recursive Neural Networks, The Challenge of Long-Term Dependencies, Leaky Units and Other Strategies for Multiple Time Scales, The Long Short-Term Memory and Other Gated RNNs, Optimization for Long-Term Dependencies, Explicit Memory	[8]

Unit IV **Deep Learning Applications and Case Studies:** Large Scale Deep Learning, Deep Learning in Computer Vision, Deep Learning in Speech Recognition, Deep Learning in Natural Language Processing, Deep Learning for Recommender Systems.	[8]
Text Books **[T1]** Goodfellow, I., Bengio, Y., Courville, A., & Bengio, Y. (2016). Deep learning. Cambridge: MIT press. **[T2]** Patterson, J., & Gibson, A. (2017). Deep learning: A practitioner's approach. " O'Reilly Media, Inc.	
Reference Books **[R1]** Duda, R. O. & Hart, P. E. (2006). Pattern Classification. John Wiley & Sons. **[R2]** Raschka, S., & Mirjalili, V. (2019).Python Machine Learning: Machine Learning and Deep Learning with Python, scikit-learn, and TensorFlow 2. Packt Publishing Limited. **[R3]** Shalev-Shwartz, S., & Ben-David, S. (2014). Understanding machine learning: From theory to algorithms. Cambridge university press.	

Paper Code : ARD372	L	P	Credit
Paper Title : Compiler Design	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: Discuss the major phases of compilers and use the knowledge of the Lex tool. [K1, K2]
CO2: Develop the parsers and experiment with the knowledge of different parsers design without automated tools. [K1, K2, K3]
CO3: Describe intermediate code representations using syntax trees and DAG's as well as use this knowledge to generate intermediate code in the form of three address code representations. [K1, K2]
CO4: Classify various storage allocation strategies and explain various data structures used in symbol tables. [K1, K2].

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

Course Content	**No of Lectures**
Unit I **Introduction to Compilers:** Definition of compiler, interpreter and its differences, the phases of a compiler, role of lexical analyzer, regular expressions, finite automata, from regular expressions to finite automata, pass and phases of translation, bootstrapping, LEX-lexical analyzer generator. **Parsing:** Parsing, role of parser, context free grammar, derivations, parse trees, ambiguity, elimination of left recursion, left factoring, eliminating ambiguity from dangling-else grammar, classes of parsing, top down parsing - backtracking, recursive descent parsing, predictive parsers, LL(1) grammars.	[7]
Unit II **Bottom Up Parsing:** Definition of bottom up parsing, handles, handle pruning, stack implementation of shift-reduce parsing, conflicts during shift-reduce parsing, LR grammars, LR parsers-simple LR, canonical LR(CLR) and Look Ahead LR (LALR) parsers, error recovery in parsing, parsing ambiguous grammars, YACC-automatic parser generator. **Syntax Directed Translation:** Syntax directed definition, construction of syntax trees, S-attributed and L-attributed definitions, translation schemes, emitting a translation.	[8]

Unit III **Intermediate Code Generation:** Intermediate forms of source programs—abstract syntax tree, polish notation and three address code, types of three address statements and its implementation, syntax directed translation into three-address code, translation of simple statements, Boolean expressions and flow-of-control statements. **Type Checking:** Definition of type checking, type expressions, type systems, static and dynamic checking of types, specification of a simple type checker, equivalence of type expressions, type conversions, and overloading of functions and operators. **Run Time Environments:** Source language issues, storage organization, storage-allocation strategies, access to non-local names, parameter passing, symbol tables, and language facilities for dynamic storage allocation.	[9]
Unit IV **Code Optimization:** Organization of code optimizers, basic blocks and flow graphs, optimization of basic blocks, the principal sources of optimization; the directed acyclic graph (DAG) representation of basic blocks; and global data flow analysis. **Code Generation:** Machine-dependent code generation, object code forms, the target machine, a simple code generator, register allocation and assignment, and peephole optimization.	[8]
Text Books **[T1]** Alfred V. Aho, Monica S. Lam, & Ravi Sethi (2023). Compilers Principles, Techniques & Tools. 2nd Edition Pearson Education. **[T2]** Tremblay, J. P, & Sorenson, P. G. (1985). The Theory and Practice of Compiler Writing. McGraw-Hill.	
Reference Books **[R1]** Holub, A. I. (1990). Compiler design in C (Vol. 924). 2nd Edition Prentice-Hall. **[R2]** Louden, K. C. (1997). Compiler Construction: Principles and Practice. Course Technology Ptr. **[R3]** Mishra, K. (2008). Theory of computer science: Automata, Languages, and Computation. 3rd Edition.	

Paper Code : ARD374	L	P	Credit
Paper Title : Supply Chain Management	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: Ability of students to understand the strategic importance of good supply chain design, planning and operation for industry. [K1, K2]
CO2: Ability of students to analyze the performance of the supply chain. [K2, K3, K4]
CO3: Ability of students to design and analyze the effective network for the supply chain. [K2, K3, K4]
CO4: Ability of students to understand the importance of coordination in supply chain. [K1, K2]

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

Course Content	No of Lectures
Unit I **Introduction:** Understanding Supply Chain, Supply Chain Performance, Supply Chain Drivers and Obstacles. **Planning Demand and Supply in a Supply Chain:** Demand Forecasting in Supply Chain, Aggregate Planning in Supply Chain, Planning Supply and Demand, Managing Predictable Variability, Economic Order Quantity Models, Reorder Point Models, Multi-Echelon Inventory Systems, Managing Uncertainty in a Supply Chain, Determining Optimal Levels of Product Availability. **Queuing theory**: Assumptions and applications of waiting line theory, M/M/1: /FCFS, M/M/K: /FCFS, M/M/K	[8]
Unit II **Supply Chain Performance:** Supply Chain Strategies, Achieving Strategic Fit, Product Life Cycle, The Minimize Local Cost View, The Minimize Functional Cost View, The Maximize Company Profit View, The Maximize Supply Chain Surplus View. **Sourcing Decisions in Supply Chains:** Role of Sourcing in Supply Chains, Supplier Assessment, Design Collaboration, Sourcing Planning and Analysis, Market Sourcing Decisions in Practice.	[8]

Unit III **Network Design:** Factors Influencing Distribution in Network Design, Distribution Networks in Practice, Framework for Network Design Decisions, Models for Facility Location and Capacity Allocation, Making Network Design Decisions in Practice, Global Supply Chain Networks. **Transportation in a Supply Chain:** Facilities Affecting Transportation Decisions, Modes of Transportation and their Performance Characteristics, Design Options for a Transport Network, Trade-offs in Transportation Decisions, Tailored Transportation, Routing and Scheduling in Transportation, Making Transportation Decisions in Practice.	[8]
Unit IV **Coordination in a Supply Chain:** Lack of Supply Chain Coordination and The Bullwhip Effect, Effect of Lack of Coordination on Performance, Obstacles to Coordination, Managerial Levers to Achieve Coordination, Achieving Coordination in Practice, Information Technology and its use in Supply Chain. **Design of efficient and sustainable Supply Chain:** Challenges in design for efficient supply chain, SCM & Environment, Enablers barriers and benefits of efficient supply chain. Case study of e-commerce and quick commerce supply chain design.	[8]
Text Books: **[T1]** Chopra, S., & Meindl, P. (2010). Supply chain management: Strategy, planning, and operation (3rd ed.). Pearson. **[T2]** Simchi-Levi, D., Kaminsky, P., & Simchi-Levi, E. (2008). Designing and managing the supply chain: Concepts, strategies, and case studies (3rd ed.). McGraw-Hill.	
Reference Books: **[R1]** Kapoor, K. K., & Kansal, P. (2003). Marketing logistics: A supply chain approach. Pearson Education Asia. **[R2]** Christopher, M. (2023). Logistics and supply chain management. Pearson.	

Paper Code : ARD376T	L	P	Credit
Paper Title : Decision Science & Analytics	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: Ability to understand the fundamental concepts, frameworks, and methodologies of decision science and analytics for data-driven decision making. [K1, K2, K3]

CO2: Ability to apply statistical techniques, exploratory data analysis, and visualization methods to derive insights from data. [K2, K3, K4]

CO3: Ability to formulate and solve optimization and decision-making problems using quantitative models and analytical tools. [K3, K4, K5]

CO4: Ability to develop predictive analytics models and evaluate intelligent decision-support systems for real-world applications. [K3, K4, K5, K6]

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

Course Content	No of Lectures
Unit I **Foundations of Decision Science and Analytics:** Introduction to Decision Science, Decision-Making Process, Rational and Behavioral Decision Models, Data-Driven Decision Making, Decision Making under Certainty, Risk, and Uncertainty, Introduction to Business and Engineering Analytics, Types of Analytics: Descriptive, Diagnostic, Predictive, Prescriptive.	[5]
Unit II **Data Analytics and Statistical Foundations:** Data Collection and Data Sources, Data Preprocessing and Cleaning, Exploratory Data Analysis (EDA), Data Visualization, Probability Theory for Decision Making, Statistical Inference, Correlation and Regression Analysis, Hypothesis Testing.	[5]
Unit III **Optimization and Decision Models:** Linear Programming, Integer Programming, Transportation and Assignment Problems, Decision Trees, Bayesian Decision Theory, Markov Decision Processes, Simulation Techniques, Multi-Criteria Decision Making (MCDM).	[5]

Unit IV **Predictive Analytics and Intelligent Decision Systems** Introduction to Machine Learning for Decision Support, Classification Techniques, Regression Models, Clustering Methods, Risk Analytics, Explainable AI (XAI), Applications in: Healthcare Analytics, Smart Cities, Cybersecurity, Finance, Supply Chain Analytics.	[5]

Text Books

[T1] Hillier, F. S., & Lieberman, G. J. (2021). Introduction to Operations Research (11th ed.). McGraw-Hill Education.
[T2] Bruce, P., Bruce, A., & Gedeck, P. (2020). Practical statistics for data scientists (2nd ed.). O'Reilly Media
[T3] Tom M. Mitchell, (1997). Machine Learning, McGraw-Hill

Reference Books

[R1] James, G., Witten, D., Hastie, T., & Tibshirani, R. (2021). An Introduction to Statistical Learning: With Applications in R (2nd ed.). Springer.
[R2] Shmueli, G., Bruce, P. C., Gedeck, P., Patel, N. R., & Lichtendahl, K. C. (2023). Data Mining for Business Analytics: Concepts, Techniques, and Applications in Python (4th ed.).

Paper Code : ARD378T	L	P	Credit
Paper Title : Edge AI	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 relation of AI and Edge Computing. [K1,K2]
CO2: Understand the computing tools and technologies of Edge AI. [K2,K3]
CO3: Apply segmentation techniques to improve efficiency of AI models and develop secured distributed Edge applications. [K3,K4,K5]
CO4: Design and Develop edge application. [K4,K5]

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

Course Content	**No of Lectures**
Unit I **Introduction to Edge Computing and AI:** **Fundamentals of Edge Computing:** Introduction, Need, Key Techniques, Benefits, Systems Paradigms of Edge computing, Edge Computing Frameworks, Value Scenarios for Edge Computing. Edge computing system architectures. Industrial Applications of Edge Computing, Intelligent Edge and Edge Intelligence, Challenges and opportunities in Edge Computing. **Fundamentals of Artificial Intelligence:** Artificial Intelligence and Deep Learning, Neural Networks in Deep Learning, Deep Reinforcement Learning, Distributed DL Training, Potential DL Libraries for Edge. Case Study: Home Edge Computing architecture (HEC)	[7]
Unit II **Edge AI Computing Tools** **Role in Edge Computing:** A high-level hardware hierarchy of edge computing paradigm, **Virtualization:** Virtual Machine and Container, Network Virtualization, Introduction to DevOps: Understanding the history and evolution, Overview of the benefits and challenges, Introduction to DevOps tools and practices, **CI/CD:** tools such as Jenkins, Travis CI, and CircleCI and CircleCI, GitLab CI/CD Setup and Configuration, installing and setting up GitLab CI/CD, Configuring GitLab CI/CD pipelines, Creating a basic CI/CD configuration file (. gitlab-ci.yml),	[9]

Case Study: Edge device toolkit providers- Google's Distributed Cloud Edge / NVIDIA Jetson platform.	
Unit III **Inference and Training in Edge AI** **Artificial Intelligence Inference in Edge:** Optimizing AI models in Edge, General method, Edge device, Overview of TensorFlow Lite (TFLite) format and its benefits, Introduction to Open Neural Network Exchange (ONNX) format and its advantages, Understanding NVIDIA TensorRT format and its optimizations for inference Segmentation of AI Model, Segmentation of AI Model, Early Exit of Inference (EEoI), Sharing of AI Computation. **Artificial Intelligence Training at Edge:** Distributed Training at Edge, Federated Learning (FL) at Edge, Communication-Efficient FL, Resource-Optimized FL, Security-Enhanced FL, **Case Study:** Machine Learning Inference at the Edge.	[8]
Unit IV **Artificial Intelligence for Optimizing Edge** **AI for Adaptive Edge Caching:** Use cases DNNs and DRL, Optimizing Edge Task Offloading, Edge Management and Maintenance: Communication, security, joint Edge optimization. Case Study: Artificial intelligence for edge service optimization in the Internet of Vehicles. **Mobile Edge AI Overview, Edge inference:** On-device inference, Computation offloading, Server-based edge inference, Device-edge joint inference, Edge training: Data partition-based, Model partition- based, Coded computing, Case Study: Energy-Efficient Mobile Edge Computing under Delay Constraints. **Artificial Intelligence Applications on Edge:** Real-time Video Analytic, Autonomous Internet of Vehicles (IoVs), Intelligent Manufacturing, Smart Home and City, Urban Healthcare, Urban Energy Management, Manufacturing, Transportation and traffic. Case study: Edge AI solution for people's data privacy and security.	[8]
Text Books **[T1]** Wang, X., Han, Y., Leung, V. C., Niyato, D., Yan, X., & Chen, X. (2020). Edge AI: Convergence of edge computing and artificial intelligence. Singapore. **[T2]** Cao, J., Zhang, Q., & Shi, W. (2018). Edge computing: a primer. Springer	
References: **[R1]** Situnayake, D., & Plunkett, J. (2023). AI at the edge: Solving real-world problems with embedded machine learning. O'Reilly Media. **[R2]** Wang, X., Han, Y., Leung, V. C. M., Niyato, D., Yan, X., & Chen, X. (2020). Edge AI: Convergence of edge computing and artificial intelligence. Springer.	

Paper Code : ARD380T	L	P	Credit
Paper Title : Web Technologies	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: Ability of students to understand the basics of web development and client side scripting. [K2] CO2: Ability of students to analyze, design and implement dynamic web pages using a combination of client side and server side scripting. [K3]
CO3: Ability of students to design and implement a full scale three tier architecture web application. [K3]
CO4: Ability of students to analyze requirements and create real time web applications using the latest technology and architectures. [K3, K4]

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

Course Content	No of Lectures
Unit I **Web Basics and Overview:** Introduction to web applications, HTML, Client Side Scripting Vs Server Side Scripting, Web Servers : Local Servers and Remote Servers, Installing Web servers, Internet Information Server (IIS), XAMPP, and NGINX web servers. Static website vs Dynamic website development. **Client Side Scripting:** Introduction to JavaScript: JavaScript language – declaring variables, scope of variables functions, event handlers (on click, on submit etc.), Document Object Model, Form validations. Simple AJAX applications.	[5]
Unit II **Basics of Go Language:** Basic data types, composite types, functions and Go methods, Goroutines and channels. receiving and processing requests, generating HTML responses with templates, Interfacing with databases.	[5]

Unit III **Go Lang and Web Applications:** Using Go for web applications, How web applications work, Go net/HTTP library, request and response, HTML Forms and Go, ResponseWriter, cookies, Handler and templates and Template engine, nesting templates. **Data model:** In-memory storage, File storage, Go and SQL, Go and SQL relationships, Go relational mappers.	[5]
Unit IV **Go Lang and its applications through case study:** Introduction to web services, SOAP and REST based web services, parsing and creating XML with Go, parsing and creating JSON with Go, Creating Go web services. A Case study of a test web application through Go and MongoDB/MySQL.	[5]
Text Books **[T1]** Chang, S. S. (2016). Go web programming. Manning. **[T2]** Donovan, A. A., & Kernighan, B. W. (2015). The Go programming language. Pearson Education.	
Reference Books **[R1]** Chisnall, D. (2012). The Go programming language phrasebook. Pearson Education. **[R2]** Lee, W.-M. (2021). Go programming language for dummies. Wiley. **[R3]** McGrath, M. (2020). Go programming in easy steps: Discover Google's Go language (Golang). In Easy Steps Limited.	

Paper Code : ARD382T	L	P	Credit
Paper Title : Metaverse and BlockChain	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 BlockChain Technology and Metaverse. [K2]
CO2: Analyze Web 3.0 technologies, decentralized applications, smart contracts, and governance models, and evaluate their integration with the Metaverse. [K2, K3]
CO3 : To Analyze the working of the Smart Contracts. [K4]
CO4: To Apply the concepts of BlockChain to design own Smart Contract and to design a BlockChain to secure Cryptocurrency information. [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	2	3	-	-	-	-	-	3
CO4	3	2	2	2	2	-	-	-	-	-	3

Course Content	**No of Lectures**
Unit I **Foundations of BlockChain Technology and Metaverse** **Introduction to Blockchain:** Definition of BlockChain. What is BlockChain? How is it used? Origin of BlockChain; Data Storage in the Blockchain. Applications of BlockChain; Advantages and Disadvantages of using Blockchains. Types of BlockChains: Public vs. Private Blockchains; Fundamental Pillars of BlockChain Technology. **Introduction to Metaverse:** Definition of Metaverse, A Brief History of Future: History of Metaverse, Applications of Metaverse, Advantages and Challenges of Metaverse, Key technologies for Metaverse-Blockchain, Augmented Reality and Virtual Reality, Artificial Intelligence, 3-D Reconstruction, IoT, Types of Metaverse, When will Metaverse arrive?, Meta businesses, Metaverse winners and losers, Metaverse existence, cryptocurrencies, and NFTs.	[5]
Unit II **Building the Metaverse:** Networking, Computing, Virtual World Engines, Interoperability, Hardware, Payment Rails **Web 3.0 and Metaverse:** Evolution of the Web with focus on Web 1.0 to Web 3.0 transition, characteristics and architecture of Web 3.0, technologies involved in Web 3.0 including Blockchain, smart contracts, decentralized storage and peer-to-peer networks, role of Artificial Intelligence in Web 3.0, decentralized applications (DApps), Decentralized Finance (DeFi), smart contracts and Decentralized	[5]

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.	