

GRAPHIC ERA (DEEMED TO BE UNIVERSITY), DEHRADUN

SEMESTER III

Name of Department: - Computer Science and Engineering

1.	Subject Code:	TCS-343	Course Title:	Mathematical Foundations for Artificial Intelligence		
2.	Contact Hours:	L: 3	T: 1	P: 0		
3.	Examination Duration (Hrs):	Theory 3	Practical 0			
4.	Relative Weight:	CIE 25	MSE 25	ESE 50		
5.	Credits:	3				
6.	Semester:	3				
7.	Category of Course:	DSE				
8.	Pre-requisite:	(TMA 101) Engineering Mathematics I, (TMA 201) Engineering Mathematics II				

9. Course Outcome:	After completion of the course, the students will be able to: CO1: Understand the basic concepts of Linear Algebra such as System of Linear Equation, Matrices, Vector Space, Rank, etc. CO2: Understand the basic principles of probability, Bayes theorem, understand the definitions of discrete, continuous, and joint random variables, compute the mean, variance and covariance of random variables. CO3: Solve problems on matrix decompositions such as Choleskey Decomposition, Eigen Decomposition and Diagonalization, Singular Value Decomposition CO4: Describe the vector calculus concepts such as differentiation of Univariate Function, Partial Differentiation and Gradients. CO5: Analyze various mathematical concepts, that are required to build AI & ML models. CO6: Create an AI & ML models by applying the concepts of mathematics such as Linear Algebra, Analytical Geometry, Matrix, Calculus, Probability, etc.
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10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	Unit 1: Linear Algebra: System of Linear Equation, Matrices, Solving system of Linear Equation, Vector Spaces, Linear Independences, Basis and Rank, Linear Mappings, Affine Space.	10
2	Unit 2: Analytic Geometry: Norms, Inner Products, Lengths and Distances, Angles and Orthogonality, Orthonormal basis, Orthogonal Compliment, Inner Product of Function, Orthogonal Projections, Rotations.	10
3	Unit 3: Matrix Decomposition Determinant and Trace, Eigen Values and Eigen Vectors, Choleskey Decomposition, Eigen Decomposition and Diagonalization, Singular Value Decomposition, Matrix Approximation, Matrix Pylogency	10
4	Unit 4: Vector Calculus Differentiation of Univariate Function, Partial Differentiation and Gradients, Gradients of Vector-Valued Functions, Gradients of Matrices, Linearization and Multivariate Taylor Series	10
5	Unit 5: Probability and Distribution Discrete and Continuous Probability, Sum Rule, Product Rule, Bayes' Theorem, Gaussian Distribution, Change of Variables/Inverse Transform	10
	Total	50

Text Books:

Authors Name	Title	Edition	Publisher, Country	Year
Marc Peter Deisenroth , A. Aldo Faisal, Cheng Soon Ong,	MATHEMATICS FOR MACHINE LEARNING	1 st	Cambridge University ,Press	2020
Jay Dawani,	Hands-On Mathematics for Deep Learning: Build a solid mathematical foundation for training efficient deep neural networks	1 st	Packt Publishing Limited, UK	2020

Reference Books:

Authors Name	Title	Edition	Publisher, Country	Year
Tamoghna Ghosh, Shravan Kumar Belagal Math, Practical Mathematics for AI and Deep Learning	Shravan Kumar Belagal Math, Practical Mathematics for AI and Deep Learning	1 st	BPB Publications ,India	2022

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
TCS343.1	Understand the basic concepts of Linear Algebra such as System of Linear Equation, Matrices, Vector Space, Rank, etc.	2	3	-	1	-	-	-	-	1	1	1	-	1	2	1
TCS343.2	Understand the basic principles of probability, Bayes theorem, understand the definitions of discrete, continuous, and joint random variables, compute the mean, variance and covariance of random variables.	-	3	-	-	1	-	-	1	1	1	1	1	1	2	1
TCS343.3	Solve problems on matrix decompositions such as Choleskey Decomposition, Eigen Decomposition and Diagonalization, Singular Value Decomposition	1	2	2	3	1	-	2	2	1	1	1	1	1	2	1
TCS343.4	Describe the vector calculus concepts such as differentiation of Univariate Function, Partial Differentiation and Gradients.	1	2	3	1	1	-	-	1	1	1	1	1	1	1	1
TCS343.5	Analyze various mathematical concepts, that are required to build AI & ML models.	-	1	2	3	1	-	1	1	1	1	1	1	2	2	1
TCS343.6	Create an AI & ML models by applying the concepts of mathematics such as Linear Algebra, Analytical Geometry, Matrix, Calculus, Probability, etc.	1	1	2	3	1	-	1	1	2	1	2	2	2	2	2
TCS 343		1.25	2.00	2.25	2.20	1.00	-	1.33	1.20	1.17	1.00	1.17	1.20	1.33	1.83	1.17

High correlation (3); Medium correlation (2); Low correlation (1), No correlation (-)

2023-24 and 2024-25 onwards

GRAPHIC ERA (DEEMED TO BE UNIVERSITY), DEHRADUN

SEMESTER III

Name of Department: - Computer Science and Engineering

1.	Subject Code:	TCS 342	Course Title:	Introduction to Statistical Data Science				
2.	Contact Hours:	L: 3	T: 1	P: 0				
3.	Examination Duration (Hrs):	Theory 3		Practical 0				
4.	Relative Weight:	CIE 25	MSE 25	ESE 50				
5.	Credits:	3						
6.	Semester:	III						
7.	Category of Course:	DSE						
8.	Pre-requisite:	Fundamental of Computer & Introduction to Programming (TCS101)						
9.	Course Outcome:	<p>After completion of the course, the students will be able to:</p> <p>CO1: Critically analyze statistical methodologies in order to assess best practice guidance when applied to real-world problems in specific contexts</p> <p>CO2: Investigate and evaluate key concepts of statistics and data science techniques and assess when to apply such techniques in practical situations</p> <p>CO3: Contextualize, implement statistical models using different statistical tools</p> <p>CO4: Develop the ability to build and assess data-based models.</p> <p>CO5: Understand fundamental principles of statistics and data science applications and technologies in order to provide strategies to address processing of datasets with a variety of characteristics.</p> <p>CO6: Apply knowledge about algorithms for statistical analysis, machine learning or data extraction in new areas within data science.</p>						

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	Unit 1: Introduction to data science: Introduction to modern data analysis, Data science components, Data Science Applications. Fundamental Statistics- Probability Distribution: Introduction to Probability, Probability Distribution (Continuous and discrete- Normal, Bernoulli, Binomial, Negative Binomial, Geometric and Poisson distribution)	10
2	Unit 2: Discrete random variables, Continuous random variable, Markov-chain Monte Carlo, Descriptive Statistics- Sample covariance, Sample covariance matrix, Outlier.	10
3	Unit 3: Concepts of Correlation, Regression, Linear square estimation, Simple Linear Regression, Multiple Regression	9
4	Unit 4: Naïve Bayes' Theorem, Bayesian classification, Central Limit theorem, Data Exploration & preparation, Confidence Interval, The hypothesis-testing, Z-Score.	8
5	Unit 5: Parametric Testing: t-Test and Z-Test, Non-parametric Testing: ANOVA and chi-Square	10
	Total	47

Text Books:

Authors Name	Title	Edition	Publisher, Country	Year
<u>Douglas C.</u> <u>Montgomery , George</u> <u>C. Runger</u>	Applied Statistics and Probability for Engineers	6 th	Wiley, United States	2016
M. Ross	Introduction to Probability and Statistics for Engineers and Scientists	4 th	Academic Press, United States	2009
James D. Miller	Statistics for Data Science	1 st	Packt Publishing Limited ,UK	2017

Reference Books:

Authors Name	Title	Edition	Publisher, Country	Year
Dr. D.C. Agarwal & Dr. Pradeep K. Joshi	Probability & Statistics for Data Science	1 st	Shree Sai Prakashan,India	2022
Dr. Mark Gardener, "Beginning R"	The Statistical Programming Language	1 st	John willey& Sons, USA	2012

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
TCS342.1	Critically analyze statistical methodologies in order to assess best practice guidance when applied to real-world problems in specific contexts	3	-	-	-	-	-	-	-	-	-	-	-	2	-	-
TCS342.2	Investigate and evaluate key concepts of statistics and data science techniques and assess when to apply such techniques in practical situations	2	2	3	-	-	-	-	-	-	-	-	2	2	3	-
TCS342.3	Contextualize, implement statistical models using different statistical tools	2	2	2	-	2	-	-	-	-	-	-	1	2	1	-
TCS342.4	Develop the ability to build and assess data-based models.	1	2	3	-	2	-	-	-	-	-	-	2	2	2	-
TCS342.5	Understand fundamental principles of statistics and data science applications and technologies in order to provide strategies to address processing of datasets with a variety of characteristics.	2	2	2	-	2	-	-	-	-	-	-	1	2	1	-
TCS342.6	Apply knowledge about algorithms for statistical analysis, machine learning or data extraction in new areas within data science.	-	-	3	1	2	-	-	-	1	1	-	1	1	2	1
TCS342		2.00	2.00	2.60	1.00	2.00	-	-	-	1.00	1.00	#DIV/0!	1.40	1.83	1.80	1.00

High correlation (3); Medium correlation (2); Low correlation (1), No correlation (-)

2023-24 and 2024-25 onwards

GRAPHIC ERA (DEEMED TO BE UNIVERSITY), DEHRADUN

SEMESTER IV

Name of Department: - Computer Science and Engineering

1.	Subject Code:	TCS 462	Course Title:	Introduction to Big Data				
2.	Contact Hours:	L: 3	T: 1	P: 0				
3.	Examination Duration (Hrs):	Theory 3		Practical 0				
4.	Relative Weight:	CIE 25	MSE 25	ESE 50				
5.	Credits:	3						
6.	Semester:	IV						
7.	Category of Course:	DSE						
8.	Pre-requisite:	(TCS-342) Introduction to Statistical Data Science, TCS-302 Data structures with C						

9. Course Outcome:	After completion of the course, the students will be able to: CO1: Outline the theory of big data, and explain challenges of big data CO2: Understand the types of Big data and its characteristics CO3: Compare Business Intelligence Vs Big Data CO4: Get the idea of NoSQL databases, different types of NoSQL/NewSQL datastores CO5: Discuss various types of Big Data analytics CO6: Elaborate a Big Data management architecture
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10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	<p>Unit 1: Big Data and its Challenges Defining Big Data, Characteristics of Big Data, Evolution of Big Data, Traditional Business Intelligence vs Big Data, The Evolution of Data Management, Understanding the Waves of Managing Data, creating manageable data structures, Web and content management, Managing big data. Building a Successful Big Data Management Architecture, beginning with capture, organize, integrate, analyze, and act, Setting the architectural foundation, Performance matters, Traditional and advanced analytics.</p>	9
2	<p>Unit 2: Big Data Types and its Sources Defining Structured Data Exploring sources of big structured data, Understanding the role of relational databases in big data Defining Unstructured Data, exploring sources of unstructured data, Understanding the role of a CMS in big data management. Looking at Real-Time and Non Real-Time Requirements, Putting Big Data Together, managing different data types, integrating data types into a big data environment.</p>	8
3	<p>Unit 3: Technology Foundations of Big Data Exploring the Big Data Stack: - Layer 0: Redundant Physical Infrastructure - Physical redundant networks, Managing hardware: Storage and servers, Infrastructure operations - Layer 1: Security Infrastructure, Interfaces and Feeds to and from Applications and the Internet- Layer 2: Operational Databases. Layer 3: Organizing Data Services and Tools. Layer 4: Analytical Data Warehouses, Big Data Analytics, Big Data Applications.</p>	9

4	Unit 4: Introduction to NoSQL and NewSQL Introduction to NoSQL, Uses, Features and Types, Need, Advantages, Disadvantages and Application of NoSQL, Overview of NewSQL. RDBMSs Are Important in a Big Data Environment. PostgreSQL relational database. Nonrelational Databases. Key-Value Pair Databases - Riak keyvalue database. Document Databases MongoDB, CouchDB . Columnar Databases, HBase columnar database. Graph Databases- Neo4J graph database.	8
5	Unit 5: Big Data Analytics Basic analytics, Advanced analytics, Operationalized analytics, Monetizing analytics. Modifying Business Intelligence Products to Handle Big Data, Studying Big Data Analytics Examples, Terminologies used in Big Data environment.	8
	Total	42

Text Books:

Authors Name	Title	Edition	Publisher, Country	Year
Judith Hurwitz, Alan Nugent , Fern Halper , Marcia Kaufman	Big Data for Dummies	1 st	Wiley, United States	2013
Subhashini Chellappan Seema Acharya	Big Data and Analytics	2 nd	Wiley, United States	2019
DT Editorial Services	Big Data	1 st	Dreamtech Press, New Dehli	2016

Reference Books:

Authors Name	Title	Edition	Publisher, Country	Year
<u>Michele Chambers,</u> <u>Michael Minelli , Ambiga Dhiraj</u>	<u>Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses</u>	1 st	Wiley, United States	2013

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
TCS462.1	Outline the theory of big data, and explain challenges of big data	3	-	-	-	-	-	-	-	1	-	1	-	-	-	1
TCS462.2	Understand the types of Big data and its characteristics	2	2	3	1	-	-	1	1	1	1	1	1	1	2	1
TCS462.3	Compare Business Intelligence vs Big Data	1	1	1	2	-	-	-	1	1	2	1	-	1	2	-
TCS462.4	Get the idea of NoSQL databases, different types of NoSQL/NewSQL data stores	3	-	-	-	-	-	-	-	-	1	1	-	1	1	-
TCS462.5	Discuss various types of Big Data analytics	1	2	3	-	-	-	-	-	1	1	1	-	-	2	-
TCS462.6	Elaborate a Big Data management architecture	-	2	-	3	1	1	-	-	1	1	1	-	1	1	-
TCS 462		2.00	1.75	2.33	2.00	1.00	1.00	1.00	1.00	1.00	1.20	1.00	1.00	1.00	1.60	1.00

High correlation (3); Medium correlation (2); Low correlation (1), No correlation (-)

GRAPHIC ERA (DEEMED TO BE UNIVERSITY), DEHRADUN

SEMESTER V

Name of Department: - Computer Science and Engineering

1.	Subject Code:	TCS562	Course Title:	Introduction to Artificial Intelligence and Data								
2.	Contact Hours:	L: 3	T: 0	P: 0								
3.	Examination Duration (Hrs):	Theory 3	Practical 0									
4.	Relative Weight:	CIE 25	MSE 25	ESE 50								
5.	Credits:	3										
6.	Semester:	V										
7.	Category of Course:	DSC										
8.	Pre-requisite:	(TCS-342) Introduction to Statistical Data Science, (TCS-462) Introduction to Big Data										
9.	Course Outcome:	After completion of the course the students will be able to: CO1: Understand the concepts of Artificial Intelligence and Data Science with their related terminologies. CO2: Analyze and Apply various programming skills for understanding Data nature and its requirements. CO3: Analyze and apply various modelling techniques for basic data Analytics. CO4: Demonstrate Problem Solving using AI algorithms. CO5: Understand, Apply and Demonstrate different techniques and tools for Data Analysis. CO6: Analyze Real World Case Studies on Applications of Data Science.										

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	<p>Unit 01:</p> <p>Data Science History, Data Science and Related Terminologies, Types of Analytics, Applications of Data Science, Data Science Process Models.</p> <p>Introduction to AI, History and Foundation of AI, Intelligence, and it's type,</p> <p>Categorization of Artificial Intelligent based System, Agents & Environments, Applications, and Current trends in AI</p>	10
2	<p>Unit 02:</p> <p>Introduction to Data, Types, Data Preprocessing, Understanding Data Requirements, Dealing with Erroneous/Missing Values, Standardizing Data, Steps involved in EDA using Python Programming/R.</p> <p>Knowledge and Reasoning in AI: Knowledge based Agents, Syntax and Semantics, Forward Chaining, Backward Chaining, Knowledge Engineering, Belief Network</p>	10
3	<p>Unit 3:</p> <p>Introduction to Modelling Techniques, Supervised Learning Algorithms- Regression, Classification, and Unsupervised Learning Algorithms- Clustering, Association Rule Mining Feature Selection, Dimensionality Reduction, Independent and Dependent Variables, Relationship between Variables: Correlation, Multicollinearity, Factor Analysis, Treatment of Outliers</p>	10
4	<p>Unit 4:</p> <p>Problem Solving Agent, Formulating Problems, Example Problems, Uninformed Search Methods, Informed Search Method, Local Search Methods, Genetic algorithms, Adversarial Search</p>	10
5	<p>Unit 5:</p> <p>Applications of Analytics in Healthcare, Applications of Analytics in Agriculture, Applications of Analytics in Business, Applications of Analytics in Sports, Forms of Learning, Introduction to Expert Systems, Expert System Architecture, Capstone Project</p>	8
	Total	48

Text Books:

Authors Name	Title	Edition	Publisher, Country	Year
Deepak Khemani	A First Course in Artificial Intelligence	6 th	McGraw Hill Education, American	2018
N. P. Padhy	Artificial Intelligence and Intelligent Systems	1 st	Oxford, England	2005
B.Uma Maheshwari, R.Sujatha	Introduction to Data Science	1 st	Wiley, United States	2021
Jake VanderPlas	Python Data Science Handbook	1 st	O'Reilly, United Kingdom	2022

Reference Books:

Authors Name	Title	Edition	Publisher, Country	Year
Stuart J. Russell and Peter Norvig	Artificial Intelligence Modern Approach	3 rd	McGraw Hill Education, American	2009

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
TCS562.1	Understand the concepts of Artificial Intelligence and Data Science with their related terminologies.	1	-	-	-	-	-	-	-	-	2	1	-	-	-	1
TCS562.2	Analyze and Apply various programming skills for understanding Data nature and its requirements.	1	2	3	-	2	-	2	2	2	1	2	1	1	1	2
TCS562.3	Analyze and apply various modelling techniques for basic data Analytics.	1	3	-	-	1	1	-	1	1	1	1	1	-	-	2
TCS562.4	Demonstrate Problem Solving using AI algorithms.	1	2	-	3	1	2	-	1	1	1	1	-	-	-	1
TCS562.5	Understand, Apply and Demonstrate different techniques and tools for Data Analysis.	1	2	3	1	2	1	2	1	1	1	2	1	-	1	2
TCS562.6	Analyze Real World Case Studies on Applications of Data Science.	2	2	3	-	3	-	3	2	1	1	2	1	2	3	1
TCS 562		1.17	2.20	3.00	2.00	1.80	1.33	2.33	1.40	1.20	1.17	1.50	1.00	1.50	1.67	1.50

High correlation (3); Medium correlation (2); Low correlation (1), No correlation (-)

GRAPHIC ERA (DEEMED TO BE UNIVERSITY), DEHRADUN

SEMESTER V

Name of Department: - Computer Science and Engineering

1.	Subject Code:	TCS 511	Course Title:	Computer Networks
2.	Contact Hours:	L: 3	T: 0	P: 0
3.	Examination Duration (Hrs):	Theory 3	Practical 0	
4.	Relative Weight:	CIE 25	MSE 25	ESE 50
5.	Credits:	3		
6.	Semester:	V		
7.	Category of Course:	DSC		
8.	Pre-requisite:	Introduction to Artificial Intelligence (XXXXXX)		
9. Course Outcome:		<p>After completion of the course the students will be able to:</p> <p>CO1: Apply and Characterize computer networks from the view point of components and from the view point of services.</p> <p>CO2: Display good understanding of the flow of a protocol in general and a network protocol in particular</p> <p>CO3: Evaluate and Select the most suitable Application Layer protocol (such as HTTP, FTP, SMTP, DNS, BitTorrent) as per the requirements of the network application and work with available tools to demonstrate the working of these protocols.</p> <p>CO4: Design a Reliable Data Transfer Protocol and incrementally develop solutions for the requirements of Transport Layer</p> <p>CO5: Describe the essential principles of Network Layers and use IP addressing to create subnets for any specific requirements</p> <p>CO6: Evaluate and select the appropriate technology to meet Data Link Layer requirements and design a framework to implementing TCP/IP protocol suite.</p>		

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	Unit 1: Introduction: Computer Networks and the Internet, Overall view: As components and as services; What is a protocol, what is a network protocol, Access Networks and Physical Media, Circuit and Packet Switching, Internet Backbone, Delays: Processing, Queuing, Transmission and Propagation delays, The Layered Architecture: Protocol Layering, The OSI Reference Model and the TCP/IP protocol stack, History of Computer Networking, and the Internet.	11
2	Unit 2: Application Layer: Principles and Architectures of Network Applications, Client and Server processes, the idea of socket, Transport services available to Application Layer especially in the internet Application Layer Protocols: The Web and http: Persistent and Nonpersistent connections, http message format, cookies, proxy server, conditional GET, File Transfer Protocol, Email: smtp, mail message formats, mail access protocols: pop3, imap, MIME, DNS: Services, How it works, Root, Top-Level and Authoritative DNS servers, Resource Records, DNS messages A simple introduction to p2p file distribution: BitTorrent	11
3	Unit 3: Transport Layer: Introduction and Services, The Transport layer in internet, Difference between Connection Oriented and Connectionless services, UDP: Segment structure, checksum in UDP, stop-and-wait, Go Back N, Selective Repeat, TCP: Connection Establishment, TCP header, Sequence and acknowledgement numbers, Round Trip Time, Flow Control, Congestion, Control. Transport Layer: Introduction and Services, The Transport layer in internet, Difference between Connection Oriented and Connectionless services UDP: Segment structure, checksum in UDP	6
4	Unit 4: Network Layer: Introduction, Packet Forwarding and Routing, Difference between Virtual Circuits and Datagram networks, The internals of a router: Input ports, output ports, switching architecture The Internet Protocol(IP), Datagram format, IP fragmentation, IPv4, addressing, subnets, CIDR, classful addressing, DHCP, Network Address Translation(NAT), Universal Plug and Play as a provider of NAT, Internet Control Message	6

	Protocol(ICMP), IPv6 Header, Moving from IPv4 to IPv6: tunnelling. Routing Algorithms: Introduction, global vs decentralized routing, The Link State(LS) Routing Algorithm, The Distance Vector (DV) Routing Algorithm, Hierarchical Routing, Introduction to Routing in the Internet: RIP, OSPF, BGP; Introduction to Broadcast and Multicast Routing.	
5	Unit 5: Link Layer and Local Area Networks: Introduction to Link Layer and its services, Where Link Layer is implemented? Error detection and correction techniques: Parity checks, Checksum, CRC; Multiple Access protocols: Channel Partitioning, Random Access (Slotted Aloha, Aloha, CSMA), Taking Turns; Link Layer Addressing: MAC addresses, ARP, Ethernet, CSMA/CD, Ethernet Technologies, Link Layer Switches, Switches vs Routers, VLANS	10
	Total	45

Text Books:

Authors Name	Title	Edition	Publisher, Country	Year
Ross and Kurose	Computer Networking: "A Top Down Approach (5th edition	7 th	Pearson/Addison-Wesley, American	2007

Reference Books:

Authors Name	Title	Edition	Publisher, Country	Year
Andrew Tanenbaum and David Wetherhall	Computer Networks	5 th	Prentice Hall, American	2010
Peterson and Davie	Computer Networks: A System Approach	4 th	Elsevier,India	2007
Forouzan	Data Communication and Networking	5 th	McGraw Hill Education, American	2013
William Stallings	Data and Computer Communication	8 th	Pearson/Addison-Wesley, American	2007
Nader F. Mir	Computer and Communication Networks	1 st	Pearson/Addison-Wesley, American	2007

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
TCS511.1	Apply and Characterize computer networks from the view point of components and from the view point of services.	2	-	-	1	2	-	1	1	1	1	-	2	2	2	1
TCS511.2	Display good understanding of the flow of a protocol in general and a network protocol in particular	1	2	-	-	1	-	1	1	1	1	-	1	2	3	2
TCS511.3	Evaluate and Select the most suitable Application Layer protocol (such as HTTP, FTP, SMTP, DNS, BitTorrent) as per the requirements of the network application and work with available tools to demonstrate the working of these protocols.	1	3	-	-	1	-	-	-	2	1	-	1	3	2	1
TCS511.4	Design a Reliable Data Transfer Protocol and incrementally develop solutions for the requirements of Transport Layer	1	1	3	-	-	-	-	-	2	1	-	1	3	3	2
TCS511.5	Describe the essential principles of Network Layers and use IP addressing to create subnets for any specific requirements	-	1	2	1	-	-	-	1	1	1	-	1	2	2	3
TCS511.6	Evaluate and select the appropriate technology to meet Data Link Layer requirements and design a framework to implementing TCP/IP protocol suite.	1	-	-	-	-	1	1	3	1	1	1	3	1	2	2
TCS511		1.20	1.75	2.50	1.00	1.33	1.00	1.00	1.50	1.33	1.00	1.00	1.50	2.17	2.33	1.83

High correlation (3); Medium correlation (2); Low correlation (1), No correlation (-)

GRAPHIC ERA (DEEMED TO BE UNIVERSITY), DEHRADUN

SEMESTER V

Name of Department: - Computer Science and Engineering

1.	Subject Code:	PCS 562	Course Title:	Introduction to AI and DS Lab		
2.	Contact Hours:	L: 0	T: 0	P: 2		
3.	Examination Duration (Hrs):	Theory		0	Practical	
4.	Relative Weight:	CIE	25	MSE	25	ESE
5.	Credits:	1				
6.	Semester:	V				
7.	Category of Course:	DSC				
8.	Pre-requisite:	(TCS-341) Python Programming for Computing, (TCS-342) Introduction to Statistical Data Science				

9. Course Outcome:	After completion of the course the students will be able to: CO1: Understand the nature of data collection, cleaning, correction. CO2: Identify the analysis and models useful to draw inferences. CO3: Explore and apply techniques designed for artificial intelligence. CO4: Analyze and apply data science and artificial intelligence to solve real world problems.
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10. Details of the Course:

Sl. No.	Contents	Contact Hours
1.	Demonstrate Data Wrangling. Using Python Using R	2
2.	Demonstrate EDA. Using Python Using R	2
3.	Demonstrate Feature Selection Techniques in Python	2
4.	Apply Informed Search on given problem	2

5.	Apply Uninformed Search on given problem	2
6.	Implement Supervised Algorithm on given dataset	2
7.	Implement Unsupervised Algorithms on given dataset	2
8.	Application and Identification of Data Cleaning Methodologies	2
9.	Identification of outliers and way to treat them	2
10.	Data Visualization of data using Python.	2
11.	Implement Classification and Regressions using Python.	2
12.	Information Extraction from Text using Python.	2
13.	Find distributions - Binomial, Poisson, Normal, distributions, their Mean and Variance, Measures of Central Tendency and Dispersion.	2
14.	Apply the concept of correlation in the given dataset.	2
15.	Using different sampling technique showcase data analysis on different dataset.	2
16.	Test Hypothesis for means and variance, T- Test, Z Test	2
17.	Fraud Detection using AI and DS	2
18.	Sentiment Analysis using AI and DS	2
19.	Text Mining using AI and DS	2
20.	Recommendation System using AI and DS	2
21.	Smart application development using AI	2
22.	Chatbot Development using AI	2
23.	Prediction System Development using AI	2
24.	An expert system development using AI	2
25.	Case Study of any health disease using AI and DS	2
	Total	50

Text Books:

Authors Name	Title	Edition	Publisher, Country	Year
Denis Rothman	Artificial Intelligence	2 nd	Packt Publishing Limited, UK	2020
Vinod Chandra S.S. , Anand Hareendran S.	Artificial Intelligence And Machine Learning	1 st	PHI Learning, India	2014

Reference Books:

Authors Name	Title	Edition	Publisher, Country	Year
John Paul Mueller	Machine Learning (in Python and R)	1 st	Wiley, United States	2016

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
PCS562.1	Understand the nature of data collection, cleaning, correction.	1	-	-	-	-	-	-	1	1	2	1	-	1	-	1
PCS562.2	Identify the analysis and models useful to draw inferences.	1	-	-	-	-	-	-	-	1	2	1	-	1	-	1
PCS562.3	Explore and apply techniques designed for artificial intelligence.	1	2	2	-	1	-	1	1	1	1	1	-	-	1	1
PCS562.4	Analyze and apply data science and artificial intelligence to solve real world problems.	2	3	-	1	1	-	-	2	1	-	2	-	1	-	1
PCS 562		1.25	2.50	2.00	1.00	1.00	-	1.00	1.33	1.00	1.67	1.25	-	1.00	1.00	1.00

High correlation (3); Medium correlation (2); Low correlation (1), No correlation (-)

GRAPHIC ERA (DEEMED TO BE UNIVERSITY), DEHRADUN

SEMESTER V

Name of Department: - Computer Science and Engineering

1.	Subject Code:	PCS 511	Course Title:	Computer Networks Lab		
2.	Contact Hours:	L: 0	T: 0	P: 2		
3.	Examination Duration (Hrs):	Theory		0	Practical	
4.	Relative Weight:	CIE	25	MSE	25	ESE
5.	Credits:	3				
6.	Semester:	V				
7.	Category of Course:	DSC				
8.	Pre-requisite:	Computer networks (TCS 511)				

9. Course Outcome:	After completion of the course the students will be able to: CO1: Understand various components that make up a computer network, including routers, switches, hubs, servers, and clients and learn about the basic commands used troubleshooting. CO2: Design UTP cable for cross and direct connection using crimping tool. CO3: Implement the common network protocols such as TCP/IP, UDP, HTTP, DNS, DHC and FTP Understand how these protocols function and their role in facilitating communication between devices using network simulation tool like Packet tracer. CO4: Apply the static and dynamic routing concepts in the network core and monitoring network traffic using Wireshark and develop skills in troubleshooting network connectivity issues. CO5: Design network applications using UDP and TCP socket programing concepts and network design principles and test these applications using real or virtual network devices.
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10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	Problem Statement 1: Familiarization of Network Environment, Understanding and using network utilities: ipconfig, netstat, ping, telnet, ftp, traceroute etc.	2
2	Problem Statement 2: Familiarization with Transmission media and tools: Co-axial cable, UTP cable, Crimping tool, Connectors etc. Preparing the UTP cable for cross and direct connection using crimping tool.	2
3	Problem Statement 3: Installation and introduction of simulation tool. (Packet Tracer)	2
4	Problem Statement 4: To configure a basic network topology consisting of routers, switches, and end devices such as PCs or laptops. Configure IP addresses and establish connectivity between devices. (Using packet Tracer)	2
5	Problem Statement 5: To configure a DHCP server on a router or a dedicated DHCP server device. Assign IP addresses dynamically to devices on the network and verify successful address assignment. (Using packet Tracer)	2
6	Problem Statement 6: To configure a local DNS server to resolve domain names within a network. (Using packet Tracer)	2
7	Problem Statement 7: To analyze complete TCP/IP protocol suite layer's headers using Wire Shark	2
8	Problem Statement 8: Static Routing: Configure static routes on multiple routers to enable communication between different networks. Test the connectivity	2

	by pinging between hosts in different networks. (Using packet Tracer)	
9	Problem Statement 9: Dynamic Routing (RIP): Configure routers to use the Routing Information Protocol (RIP) for dynamic routing. Enable RIP on the interfaces connected to different networks and verify that routes are being learned and propagated. Test the connectivity between hosts in different networks. (Using packet Tracer)	2
10	Problem Statement 10: Dynamic Routing (OSPF): Configure routers to use the Open Shortest Path First (OSPF) routing protocol. Set up OSPF on the routers and advertise network information. Verify that OSPF is establishing neighbor relationships and propagating routes. Test connectivity between hosts in different networks. (Using packet Tracer)	2
11	Problem Statement 11: TCP Client-Server Communication: Implement a TCP client program that sends a message to a TCP server program. Implement the corresponding TCP server program that receives the message and displays it. Test the communication between the client and server by exchanging messages (Using 'C' Language)	2
12	Problem Statement 12: UDP Client-Server Communication: Implement a UDP client program that sends a message to a UDP server program. Implement the corresponding UDP server program that receives the message and displays it (Using 'C' Language)	2
1.	Optional programs for advanced learner Problem Statement 1: File Transfer using TCP: Implement a TCP server program that listens for incoming connections.	2

	<p>Implement a TCP client program that sends a file to the server. The server should receive the file and save it on the local machine. Verify the successful transfer by comparing the original file with the received file</p>	
2.	<p>Problem Statement 2:</p> <p>Chat Application using TCP:</p> <p>Implement a TCP client program for a chat application.</p> <p>Implement the corresponding TCP server program.</p> <p>Multiple clients should be able to connect to the server and exchange messages.</p> <p>Test the chat application by simulating multiple clients communicating with each other.</p>	2
3.	<p>Problem Statement 3:</p> <p>DNS Lookup using UDP:</p> <p>Implement a UDP client program that sends a domain name to a DNS server.</p> <p>Implement the corresponding DNS server program that resolves the domain name to an IP address.</p> <p>The server should send the resolved IP address back to the client.</p> <p>Test the program by performing DNS lookups for different domain names</p>	2
4.	<p>Problem Statement 4:</p> <p>HTTP Server using TCP:</p> <p>Implement a TCP server program that acts as an HTTP server.</p> <p>The server should be able to handle HTTP requests and send back appropriate HTTP responses.</p> <p>Test the server by accessing it through a web browser and requesting different resources.</p>	2
5.	<p>Problem Statement 5:</p> <p>Virtual LANs (VLANs): Create multiple VLANs and configure inter-VLAN routing using a router or Layer 3 switch. Assign hosts to different VLANs and test communication between hosts in different VLANs.</p>	2
6.	<p>Problem Statement 6:</p> <p>Access Control Lists (ACLs): Implement access control lists on routers to control traffic flow based on source/destination IP</p>	2

	addresses, port numbers, or protocols. Test the ACLs by allowing or denying specific types of traffic between hosts.	
7.	Problem Statement 7: Network Address Translation (NAT): Configure Network Address Translation on a router to translate private IP addresses to public IP addresses and vice versa. Test connectivity between hosts with private IP addresses and hosts on the public internet.	2
	Total	38

Text Books:

Authors Name	Title	Edition	Publisher, Country	Year
Behrouz A. Forouzan	Data Communications and Networking with TCPIP Protocol Suite	5 th	McGraw Hill Education, American	2022

Reference Books:

Authors Name	Title	Edition	Publisher, Country	Year
Ross and Kurose	Computer Networking: "A Top-Down Approach	6 th	Pearson/Addison-Wesley, American	2017

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
PCS511.1	Understand various components that make up a computer network, including routers, switches, hubs, servers, and clients and learn about the basic commands used troubleshooting.	-	1	-	-	-	1	-	-	1	2	-	1	2	2	3
PCS511.2	Design UTP cable for cross and direct connection using crimping tool.	1	2	-	-	-	-	-	-	1	1	-	1	2	1	3
PCS511.3	Implement the common network protocols such as TCP/IP, UDP, HTTP, DNS, DHC and FTP Understand how these protocols function and their role in facilitating communication between devices using network simulation tool like Packet tracer.	1	3	-	1	-	1	-	-	1	1	-	2	3	2	1
PCS511.4	Apply the static and dynamic routing concepts in the network core and monitoring network traffic using Wireshark and develop skills in troubleshooting network connectivity issues.	1	2	-	3	2	-	-	-	1	1	-	2	2	2	3
PCS511.5	Design network applications using UDP and TCP socket programming concepts and network design principles and test these applications using real or virtual network devices.	3	-	-	-	1	1	-	-	1	-	2	2	2	3	2
PCS511.6		1	1	3	1	1	-	-	-	2	1	2	2	2	2	3
PCS511		1.40	1.80	3.00	1.67	1.33	1.00	-	-	1.17	1.20	2.00	1.80	2.17	2.00	2.50

High correlation (3); Medium correlation (2); Low correlation (1), No correlation (-)

GRAPHIC ERA (DEEMED TO BE UNIVERSITY), DEHRADUN

SEMESTER V

Name of Department: - Computer Science and Engineering

1.	Subject Code:	TCS 563	Course Title:	Multi-Modal Data Processing and Learning
2.	Contact Hours:	L: 3	T: 1	P: 0
3.	Examination Duration (Hrs):	Theory 4	Practical 0	
4.	Relative Weight:	CIE 25	MSE 25	ESE 50
5.	Credits:	3		
6.	Semester:	V		
7.	Category of Course:	DSE		
8.	Pre-requisite:			
9.	Course Outcome:	After completion of the course the students will be able to: CO1: To discuss multimodal data and its applications CO2: To apply text processing techniques in the relevant applications CO3: To analyze various speech processing approaches CO4: To create a model based on digital image and video processing CO5: To analysis data of imbalance for multimodal design CO6: To compare various types of processing such as Text process, Speech processing, Image and Video processing		

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	Unit 1: Introduction: Introduction to Multimodal data and applications, Challenges of multimodal data, Data collection & cleaning.	8
2	Unit 2: Text Processing: Text normalization, Lemmatization, Morphology, Subword tokenization; Text processing and statistics: TFIDF, BM-25,	9

	Zipf's law, Hipf's law; Language models and smoothing techniques; Vector space models.	
3	Unit 3: Speech Processing: Speech production and perception, Acoustic and articulatory phonetics; Short-term analysis: Need and windowing, Energy, Zero-crossing rate, Autocorrelation function, Fourier transform, Spectrogram; Short-term synthesis: Overlap-add method; Cepstrum analysis: Basis and development, mel-cepstrum.	9
4	Unit 4: Digital Image and Video Processing: Point processing, Neighborhood processing, Enhancement, Edge detection, Segmentation, Feature descriptors, Restoration, Morphological operations, Image transforms, Spatial and temporal data handling.	9
5	Unit 5: Multi-modal data synchronization and fusion: Data understanding and quality estimation, meta data filtering, amount of data estimation for multimodal design, data synchronization and fusion, imbalance data analysis for multimodal design.	8
Total		43

Text Books:

Authors Name	Title	Edition	Publisher, Country	Year
R. C. Gonzalez, R. E. Woods	<i>Digital Image Processing</i> , Pearson	1 st	Prentice Hall, American	2008
R. Klette	<i>Concise Computer Vision: An Introduction Into Theory And Algorithms</i>	1 st	Springer	2014
L. R. Rabiner, R. W. Schafer	<i>Introduction To Digital Speech Processing</i>	1 st	Now Publishers Inc	2007
A But, A Miasnikov, G Ortolani, Multimodal	Deep Learning With Tensorflow: Translate Mathematics Into	1 st	Packt Publishing Limited, UK	2019

	Robust Tensorflow Applications With Python			
M Yang, B Rosenhahn, V Murino	Multimodal Scene Understanding: Algorithms, Applications And Deep Learning	1 st	Academic Press, United States	2019

Reference Books:

Authors Name	Title	Edition	Publisher, Country	Year
D. Jurafsky, J.H. Martin	<i>Speech And Language Processing,</i>	3 rd	Pearson/Addison-Wesley, American	2022
J-P Thiran, F Marqués And H Bourlard	Multimodal Signal Processing: Theory And Applications For Human-Computer Interaction	1 st	Academic Press, United States	2009

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
TCS563.1	To discuss multimodal data and its applications	1	1	-	-	-	-	-	-	1	2	-	1	2	1	3
TCS563.2	To apply text processing techniques in the relevant applications	1	2	-	-	-	-	-	-	1	2	1	1	2	1	2
TCS563.3	To analyze various speech processing approaches	-	2	-	-	2	1	-	-	1	2	-	-	3	2	2
TCS563.4	To create a model based on digital image and video processing	-	3	1	3	2	-	-	-	1	1	1	1	3	2	2
TCS563.5	To analysis data of imbalance for multimodal design	2	2	-	1	1	1	-	-	1	1	1	1	3	1	2
TCS563.6	To compare various types of processing such as Text process, Speech processing, Image and Video processing	-	1	3	1	2	-	-	-	1	-	1	2	3	2	2
TCS 563		1.33	1.83	2.00	1.67	1.75	1.00	-	-	1.00	1.60	1.00	1.20	2.67	1.50	2.17

High correlation (3); Medium correlation (2); Low correlation (1), No correlation (-)

GRAPHIC ERA (DEEMED TO BE UNIVERSITY), DEHRADUN

SEMESTER V

Name of Department: - Computer Science and Engineering

1.	Subject Code:	TCS 549	Course Title:	Data Science: Visualization with Tableau Specialization								
2.	Contact Hours:	L: 3	T: 1	P: 0								
3.	Examination Duration (Hrs):	Theory 4	Practical 0									
4.	Relative Weight:	CIE 25	MSE 25	ESE 50								
5.	Credits:	3										
6.	Semester:	V										
7.	Category of Course:	DSE										
8.	Pre-requisite:											
9.	Course Outcome:	After completion of the course the students will be able to: CO1: Clean up, format and analyze data to prepare for interactives CO2: Design visualizations that represent the relationships contained in complex data sets and adapt them to highlight the ideas we want to communicate CO3: Use principles of human perception and cognition in visualization design. CO4: Identify the statistical analysis needed to validate the trends present in data visualizations. CO5: Critically evaluate visualizations and suggest improvements and refinements. CO6: Use leading open source and commercial software packages (Tableau) to create and publish visualizations that enable clear interpretations of big, complex and real world data										

10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	<p>UNIT 01:</p> <p>Context of Data Visualization: Visualization as a discovery tool, Bedrock of visualization as a discovery tool, Visualizing the past, Different Data Visuals for Different Needs, The classic case of London 1855 cholera epidemic and how it changed the face of visualization, The 20th Century advancements, Computer-based Visualization, The Power of Human Perception, Different Data Calls for Different Views, Leveraging Composition and Interactivity, Using Data to Tell Stories</p> <p>Visualization design objectives: Methodology, Establishing intent, The visualization's function-explain, explore, exhibit; Tone-analytical and abstract, key factors in a visualization project, The eight hats of data visualization design</p>	10
2	<p>UNIT 02:</p> <p>Demonstrating Editorial Focus: Importance of editorial focus, Preparing and familiarizing of data, Refining the editorial focus, Using visual analysis to find stories</p> <p>Conceiving and Reasoning: Preparing data, Refining, The Visualization anatomy - Data Representation: choosing correct visualization method, physical properties of data, degree of accuracy in interpretation, creating an appropriate design metaphor, choosing the final solution; The Visualization anatomy- Data presentation: Interactivity, Annotation and Arrangement</p>	10
3	<p>Unit 03:</p> <p>Taxonomy of Data Visualization: Choosing appropriate chart type: Dot plot, Column chart, Floating bar(Gantt chart), pixelated bar chart, Histogram, Slopegraph, Radial chart, Glyph chart, Sankey diagram, Area size chart; Assessing hierarchies and part-to-whole relationships: Pie chart, Stacked bar chart, Square pie,</p>	9

	Tree map, Circle packing diagram, Bubble hierarchy, Tree Hierarchy; Showing changes over time: Line chart, Sparklines, Area chart, Horizon chart, Stacked area chart, Candlestick chart (or box and whiskers plot, OHLC chart), Barcode chart, Flow map; Plotting connections and relationships: Scatter plot, Bubble plot, Scatter plot matrix, Heatmap, Parallel sets, Radial network, Network Diagram; Mapping geo-spatial data: Choropleth map, dot plot map, Bubble plot map , Isarithmic map	
4	<p>Unit 04:</p> <p>Collaborative Visual Analysis: Supporting Asynchronous Collaborative Information Visualization, Designing for social data analysis, Design considerations for collaborative visual analytics</p> <p>Constructing and Evaluating the Design Solution: Nested model for visualization design and validation, Challenge of information visualization evaluation, Visualization software, applications and programs; Charting and statistical analysis tools, programming environments, tools for mapping, The construction process, Approaching the finishing line, Post-launch evaluation, Developing the capabilities</p>	9
5	<p>Unit 05:</p> <p>Data Visualization through Tableau: Tableau basics, connecting tableau to various datasets, creating bar charts, area charts, maps, scatterplots, pie charts, tree maps; Create Interactive Dashboards, storylines, Joins, Data Blending, Table calculations, parameters, Dual axis charts, Export results from Tableau to other software, Work with timeseries data, Creating data extracts, Aggregation, Granularity and Level of detail, Adding filters, create data hierarchies, Adding actions to dashboards</p>	8
	Total	46

Text Books:

Authors Name	Title	Edition	Publisher, Country	Year
Andy Kirk	Data Visualization: a successful design process	1 st	Packt Publishing Limited, UK	2012

Reference Books:

Authors Name	Title	Edition	Publisher, Country	Year
Tamara Munzer	Visualization Analysis and Design	1 st	CRC Press, United States	2014

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
TCS549.1	Clean up, format and analyze data to prepare for interactives	3	1										1		1	2
TCS549.2	Design visualizations that represent the relationships contained in complex data sets and adapt them to highlight the ideas we want to communicate	2	2		1									2	1	
TCS549.3	Use principles of human perception and cognition in visualization design.	1	1		2	1			1				2	2	1	
TCS549.4	Identify the statistical analysis needed to validate the trends present in data visualizations.	3	1		1				1				1	1	2	1
TCS549.5	Critically evaluate visualizations and suggest improvements and refinements.	3	2			1			1			1	1	2	1	1
TCS549.6	Use leading open source and commercial software packages (Tableau) to create and publish visualizations that enable clear interpretations of big, complex and real world data	3	2		2	1			1			1	1	1	1	1
TCS 549		2.50	1.50	-	1.50	1.00	-	-	1.00	-	-	1.00	1.20	1.50	1.33	1.20

High correlation (3); Medium correlation (2); Low correlation (1), No correlation (-)

GRAPHIC ERA (DEEMED TO BE UNIVERSITY), DEHRADUN

SEMESTER VI

Name of Department: - Computer Science and Engineering

1.	Subject Code:	TCS 662	Course Title:	Machine Learning
2.	Contact Hours:	L: 3	T: 0	P: 0
3.	Examination Duration (Hrs):	Theory 3	Practical 0	
4.	Relative Weight:	CIE 25	MSE 25	ESE 50
5.	Credits:	3		
6.	Semester:	VI		
7.	Category of Course:	DSC		

8. Pre-requisite: Design and Analysis of Algorithm (TCS 409), Fundamental of Statistics and AI (TCS 421), Statistical Data Analysis with R (TCS 471), Discrete Structures and Combinatorics (TMA 316)

9. Course Outcome:	After completion of the course the students will be able to: CO1: Acquire concepts and methods in statistical machine learning CO2: Analyze fundamental principles of machine learning algorithms CO3: Understand machine learning motivated by case-studies CO4: Investigate and evaluate key topics in machine learning algorithms for data science industry
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10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	Unit 1: Machine learning foundation Review of logic and knowledge system - language, axiom, hypothesis, theorem, logic & types, what is ML, Inductive bias in ML, AI pyramid, Pattern classification pipeline, Linear algebra in ML, Probabilistic logic and statistical inference (Random expt./	14

	variable, CDF, WLLN, Bayes, Markov & Chernoff bound, Hypothesis testing and performance indices - ROC, Estimation - detection, Optimality of Bayes, bias-variance, underfit-overfit, entropy as Information, Cover's packing lemma, Curse of dimensionality, Case study: Wealth – optimal payoffs in portfolios (stock market)	
2	Unit 2: Unsupervised Learning Clustering, Clustering methods – Partition vs. Hierarchical, k-Means and k-Medoids, Hierarchical: Agglomerative & Divisive, Error Analysis in Clustering, Ensemble - clustering, Case study: Clustering in Health care, Causal cluster, Graph cluster	8
3	Unit 3: Supervised Learning Main objectives and types of Supervised methods (Parametric, Semi parametric, Non-parametric), Linear Regression and Weiner filter, Grammar based/ Inductive learning - Decision Trees – CART, ID-3, Pruning metrics for tree; D-tree examples, Linear SVM (basics and V-C bound), k-NN rule and examples, Learning as Factorization, Ensemble learning: Bagging, Boosting. Case studies: covered for mentioned Supervised learning techniques.	10
4	Unit 4: Reinforcement & Interaction Learning Basic model of Reinforcement Learning as game (Agent, Critic, Environment), Optimal policy & Q – values, Bellman equation, Case studies on R Learning Active learning, Deep Reinforcement, Transfer learning with examples, Federated Machine Learning with examples.	8
5	Unit 5: Special topics in Machine Learning Sentiment Mining: NLP pipeline process, Data Analytics – Big data and Hadoop model, Business Analytics – Competitive Machine Learning, ANN building blocks (problem solving), Deep learning, Feed forward, Backpropagation, C-NN, Recurrent-NN.	8
	Total	48

Text Books:

Authors Name	Title	Edition	Publisher, Country	Year
R, Duda, P. Hart and D. Stork	Pattern classification	2 nd	Wiley, United States	2007
J. Friedman, R. Tibshirani and T. Hastie	The Elements of Statistical Learning	3 rd	Springer Publisher, German	2017
C. Bishop	Pattern Recognition and Machine Learning	2 nd	Springer Publisher, German	2016
A. Courville, I. Goodfellow, Y. Bengio	Deep Learning	2 nd	MIT Press,United States	2016

Reference Books:

Authors Name	Title	Edition	Publisher, Country	Year
Tom M. Mitchell	Machine Learning	1 st	McGraw Hill Education, American	2017
E. Alpaydin	Introduction to Machine Learning	3 rd	PHI Learning,India	2015
T M. Cover, J A. Thomas	Elements of Information Theory	2 nd	Wiley, United States	2006

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
TCS662.1	Acquire concepts and methods in statistical machine learning	1	1	-	1	2	-	-	-	1	2	-	1	2	1	2
TCS662.2	Analyze fundamental principles of machine learning algorithms	2	3	-	-	1	-	-	-	1	-	-	-	3	2	2
TCS662.3	Understand machine learning motivated by case-studies	1	1	-	3	-	-	-	-	2	-	1	2	3	2	2
TCS662.4	Investigate and evaluate key topics in machine learning algorithms for data science industry	1	1	3	2	3	-	-	-	2	1	-	-	3	1	2
TCS 662		1.25	1.50	-	1.50	2.00	-	-	-	1.50	1.50	1.00	1.00	2.75	1.67	2.00

High correlation (3); Medium correlation (2); Low correlation (1), No correlation (-)

GRAPHIC ERA (DEEMED TO BE UNIVERSITY), DEHRADUN

SEMESTER VI

Name of Department: - Computer Science and Engineering

1.	Subject Code:	TCS 662	Course Title:	Machine Learning Lab
2.	Contact Hours:	L: 3	T: 1	P: 0
3.	Examination Duration (Hrs):	Theory 3	Practical 0	
4.	Relative Weight:	CIE 25	MSE 25	ESE 50
5.	Credits:	3		
6.	Semester:	VI		
7.	Category of Course:	DSE		

8. Pre-requisite: Design and Analysis of Algorithm (TCS 409), Python programming (TCS 341) or C++ programming (TCS 307) or Java Programming (TCS 408)

9. Course Outcome:	After completion of laboratory the students will be able to: CO1: Implement methods in statistical machine learning CO2: Analyze data and machine learning algorithms CO3: Understand machine learning motivated by case-studies
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10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	To implement various similarity functions for attribute tuples stored as .csv file – Euclidean, Manhattan, Cosine.	2
2	To use lobe.ai user interface and perform manual labeling, training and testing for supervised object recognition in Image	2
3	To understand and develop basic KR (Knowledge Representation) Tools from practical AI problem definitions: KR methods	2

4	To take two - category input file and use thresholding to design binary classifier for 1 feature, for 2 feature dataset	2
5	To register and use monkeylearn.com and create model, train and classify sentiments that lead to sentiment prediction using corpus of hotel reviews as part of NLU	2
6	To register and use Teachable machine (Google API) and perform multiple class / pose analysis and classification.	2
7	To use quillbot.com and study basic machine transcription roles in summarization: as NLP application	2
8	To use quillbot.com and study basic machine transcription roles in grammar checker (syntax): as NLP application	2
9	To use quillbot.com and study basic machine transcription roles in paraphrasing: as NLP application	2
10	To create multiple clusters using PoS (parts of speech) data by reading input text file	2
11	To create multiple clusters from column data entries of .csv file using k-means algorithm	2
12	To create multiple clusters by using hierarchical clustering – Agglomerative based on .csv file	2
13	To use healthcare dataset and form scatter plot with observed statistical measures	2
14	To import tabular data for related clinical parameters and program a basic linear regression model	2
15	Program probabilistic model given: it is Friday and that a student is absent is 3 %. Since there are 5 school days in a week, the probability that it is friday is 20 %. What is the probability that a student is absent given that today is friday. Program Bayesian rule in python to get the result.	2
16	To extract intra-day stock market data for 4 stocks and write program that: plots the values, develops linear regression, derive mean and correlation.	2
17	To write program that can import training samples for 3 labels and perform k-NN for new queries and quantify error performance	2
1	Unit 1: Basic Concepts: Formulation of mathematical programming problems; Classification of optimization problems; Optimization techniques – classical and advanced techniques Optimization using Calculus: Convexity and concavity of functions of one and	10

	two variables; Optimization of function of multiple variables subject to equality constraints; Lagrangian function; Optimization of function of multiple variables subject to equality constraints; Hessian matrix formulation	
2	Unit 2: Linear Programming: Standard form of linear programming (LP) problem; Canonical form of LP problem; Assumptions in LP Models; Graphical method for two variable optimization problem; Motivation of simplex method, Simplex algorithm and construction of simplex tableau; Revised simplex method; Duality in LP; Primal dual relations; Dual Simplex Method; Sensitivity or post optimality analysis; bounded variables	10
3	Unit 3: Dynamic Programming: Representation of multistage decision process; Types of multistage decision problems; Concept of sub optimization and the principle of optimality	8
4	Unit 4: Integer Programming: Integer linear programming; Branch and Bound algorithm; Concept of cutting plane method; Mixed integer programming; Solution algorithms.	8
5	Unit 5: Advanced Topics in Optimization: Direct and indirect search methods; Heuristic and Meta-Heuristic Search methods; Multi objective optimization.	8
	Total	

Text Books:

Authors Name	Title	Edition	Publisher, Country	Year
S.S. Rao	Engineering Optimization: Theory and Practice	3 rd	New Age International Publishers, India	2013
H.A. Taha	Operations Research: An Introduction	10 th	Pearson/Addison-Wesley, American	2019
Ravindran, K. M. Ragsdell and G. V. Reklaitis	Engineering Optimization: Methods and Applications	2 nd	Wiley, India	2006

Reference Books:

Authors Name	Title	Edition	Publisher, Country	Year
R. Fletcher	Practical Methods of Optimization	2 nd	Wiley, India	2009
K. Deb	Optimization for Engineering Design	2 nd	Prentice Hall ,India	2012

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
PCS662.1	Implement methods in statistical machine learning	3	-	3	1	1	-	-	1	-	1	-	1	2	3	2
PCS662.2	Analyze data and machine learning algorithms	1	1	2	3	-	-	-	-	1	2	-	1	3	2	1
PCS662.3	Understand machine learning motivated by case-studies	1	3	1	-	-	-	-	-	1	1	-	1	2	3	2
TEE 602		1.67	2.00	2.00	2.00	1.00	-	-	1.00	1.00	1.33	-	1.00	2.33	2.67	1.67

High correlation (3); Medium correlation (2); Low correlation (1), No correlation (-)

GRAPHIC ERA (DEEMED TO BE UNIVERSITY), DEHRADUN

SEMESTER VI

Name of Department: - Computer Science and Engineering

1.	Subject Code:	TCS 663	Course Title:	Big Data Analytics: Tools and Techniques
2.	Contact Hours:	L: 3	T: 1	P: 0
3.	Examination Duration (Hrs):	Theory 4	Practical 0	
4.	Relative Weight:	CIE 25	MSE 25	ESE 50
5.	Credits:	3		
6.	Semester:	VI		
7.	Category of Course:	DSE		
8.	Pre-requisite:	Introduction to Big Data (TCS-462), Big Data Visualization (TCS-571), Data Base Management Systems (TCS-503), Programming in Java (TCS-408),		

9. Course Outcome:	After completion of the course the students will be able to: CO1: Investigate Hadoop related tools for Big Data Analytics and perform basic Hadoop Administration CO2: Analyse the technological foundations for Big data with Hadoop and design of Hadoop distributed file system CO3: Understand the concept of MapReduce workflow CO4: Develop program using Hive and Apache Pig for large data processing CO5: Outline the theory of big data, and explain applications of big data CO6:Build Big Data Analytics application to solve real world problem
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10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	Unit 1: Introduction to Hadoop: Introduction to Hadoop, Distributed Computing Challenges, Hadoop Features, Hadoop Distributed File	9

	System (HDFS), Hadoop Versions, Hadoop Installation, HDFS basic commands, Overview of Hadoop Ecosystem, RDMS vs Hadoop	
2	Unit 2: Introduction to MapReduce Programming: Introduction to MapReduce Framework, Mapper, Reducer, Combiner, Partitioner, Searching, Sorting, Compression, Sample programs on MapReduce, Techniques to optimize MapReduce Jobs	8
3	Unit 3: Hive and Apache Pig Hive: Introduction to Hive, Hive Architecture, Hive Data Types, Hive Query Language, User Defined Functions, Sample Programs Apache Pig: Introduction to Pig, Pig Latin Overview, Data Types in Pig, Pig Operators, User Defined Functions, Sample Programs	8
4	Unit 4: Spark: Introduction to Spark, Features of Spark, Spark Architecture, Spark Components, Spark RDD, Spark in-built functions, Sample Programs	9
5	Unit 5: Apache Flume, Sqoop and Big Data Applications Flume: Introduction to Apache Flume, Flume Architecture, Data Flow, Environment, Sample Exercise Sqoop: Introduction to Sqoop, Sqoop Features, Sqoop Architecture, Sqoop integration with Hadoop, Data import and export using Sqoop, Sqoop vs Flume, Sample Exercise Big Data Applications: Healthcare, Agriculture, Education, Media and Entertainment, Travel, Retail, etc.	8
	Total	42

Text Books:

Authors Name	Title	Edition	Publisher, Country	Year
<u>Subhashini</u> <u>Chellappan</u> <u>Seema</u> <u>Acharya</u>	Big Data and Analytics	2 nd	Wiley, India	2019
DT Editorial Services	Big Data	1 st	Dreamtech Press, New Dehli	2016
Raj Kamal	Big Data Analytics, Introduction to Hadoop, Spark, and Machine-Learning	1 st	McGraw Hill Education, American	2019

Reference Books:

Authors Name	Title	Edition	Publisher, Country	Year
<u>Tom White</u>	<u>Hadoop: The Definitive Guide</u>	4 th	O'Reilly, United Kingdom	2015
<u>Michele Chambers,</u> <u>Michael</u> <u>Minelli , Ambiga</u> <u>Dhiraj</u>	<u>Big Data, Big Analytics: Emerging Business Intelligence and Analytic</u>	1 st	Wiley, India	2013

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
TCS663.1	Investigate Hadoop related tools for Big Data Analytics and perform basic Hadoop Administration	-	1	-	1	-	-	-	-	1	1	-	1	2	2	2
TCS663.2	Analyse the technological foundations for Big data with Hadoop and design of Hadoop distributed file system	1	3	-	1	1	-	1	-	1	1	-	2	3	2	2
TCS663.3	Understand the concept of MapReduce workflow	-	-	3	3	2	-	-	1	-	1	1	2	2	2	2
TCS663.4	Develop program using Hive and Apache Pig for large data processing	3	-	1	1	1	-	-	1	-	1	-	1	2	3	2
TCS663.5	Outline the theory of big data, and explain applications of big data	1	1	2	3	-	-	-	-	1	2	-	1	3	2	1
TCS663.6	Build Big Data Analytics application to solve real world problem	1	3	1	-	-	-	-	-	1	1	-	1	2	3	2
TCS 663		1.50	2.00	1.75	1.80	1.33	-	1.00	1.00	1.00	1.17	1.00	1.33	2.33	2.33	1.83

High correlation (3); Medium correlation (2); Low correlation (1), No correlation (-)

GRAPHIC ERA (DEEMED TO BE UNIVERSITY), DEHRADUN

SEMESTER VII

Name of Department: - Computer Science and Engineering

1.	Subject Code:	TCS 762	Course Title:	NoSQL Database
2.	Contact Hours:	L: 3	T: 0	P: 0
3.	Examination Duration (Hrs):	Theory 3	Practical 0	
4.	Relative Weight:	CIE 25	MSE 25	ESE 50
5.	Credits:	3		
6.	Semester:	VII		
7.	Category of Course:	DSC		
8.	Pre-requisite:	(TCS 663) Big Data Analytics: Tools and Techniques, (TCS 462) Introduction to Big Data		

9. Course Outcome:	After completion of the course the students will be able to: CO1: Demonstrate an understanding of the detailed architecture of Column Oriented NoSQL databases, Document databases, Graph databases. CO2: Make use of the concepts pertaining to all the types of databases CO3: Apply performance tuning on Column-oriented NoSQL databases and Document-oriented NoSQL Databases. CO4: Analyze the structural Models of NoSQL. CO5: Evaluate several applications for location based service and recommendation services. Devise an application using the components of NoSQL. CO6: Develop various applications using NoSQL databases.
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10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	Unit 1: Introduction to Hadoop: Introduction to Hadoop, Distributed Computing Challenges, Hadoop Features, Hadoop Distributed File System (HDFS), Hadoop Versions, Hadoop Installation, HDFS basic commands, Overview of Hadoop Ecosystem, RDMS vs Hadoop	9
2	Unit 2: Introduction to MapReduce Programming: Introduction to MapReduce Framework, Mapper, Reducer, Combiner, Partitioner, Searching, Sorting, Compression, Sample programs on MapReduce, Techniques to optimize MapReduce Jobs	8
3	Unit 3: Hive and Apache Pig Hive: Introduction to Hive, Hive Architecture, Hive Data Types, Hive Query Language, User Defined Functions, Sample Programs Apache Pig: Introduction to Pig, Pig Latin Overview, Data Types in Pig, Pig Operators, User Defined Functions, Sample Programs	8
4	Unit 4: Spark: Introduction to Spark, Features of Spark, Spark Architecture, Spark Components, Spark RDD, Spark in-built functions, Sample Programs	9
5	Unit 5: Apache Flume, Sqoop and Big Data Applications Flume: Introduction to Apache Flume, Flume Architecture, Data Flow, Environment, Sample Exercise Sqoop: Introduction to Sqoop, Sqoop Features, Sqoop Architecture, Sqoop integration with Hadoop, Data import and export using Sqoop, Sqoop vs Flume, Sample Exercise Big Data Applications: Healthcare, Agriculture, Education, Media and Entertainment, Travel, Retail, etc.	8
	Total	42

Text Books:

Authors Name	Title	Edition	Publisher, Country	Year
Sadalage, P. & Fowler	NoSQL Distilled: A Brief Guide to the Emerging World of Polyglot Persistence	1 st	Pearson/Addison-Wesley, American	2012

Reference Books:

Authors Name	Title	Edition	Publisher, Country	Year
Dan Sullivan	NoSQL For Mere Mortals	1 st	Pearson Education India	2015
Dan McCreary and Ann Kelly	Making Sense of NoSQL: A guide for Managers and the Rest of us	1 st	Dreamtech Press, New Dehli	2013
Kristina Chodorow	Mongodb: The Definitive Guide- Powerful and Scalable Data Storage	2 nd	O'Reilly, United Kingdom	2013

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
TCS762.1	Demonstrate an understanding of the detailed architecture of Column Oriented NoSQL databases, Document databases, Graph databases.	-	3	-	1	-	-	-	-	1	1	-	1	2	2	2
TCS762.2	Make use of the concepts pertaining to all the types of databases	1	1	3	1	1	-	1	-	1	1	-	2	3	2	2
TCS762.3	Apply performance tuning on Column-oriented NoSQL databases and Document-oriented NoSQL Databases.	3	-	-	3	2	-	-	1	-	1	1	2	2	2	2
TCS762.4	Analyze the structural Models of NoSQL.	1	-	1	3	1	-	-	1	-	1	-	1	2	3	2
TCS762.5	Evaluate several applications for location based service and recommendation services. Devise an application using the components of NoSQL.	3	1	-	-	-	-	-	-	1	2	-	1	3	2	1
TCS762.6	Develop various applications using NoSQL databases.	1	-	1	3	-	-	-	-	1	1	-	1	2	3	2
TCS 762		1.80	1.67	1.67	2.20	1.33	-	1.00	1.00	1.00	1.17	1.00	1.33	2.33	2.33	1.83

High correlation (3); Medium correlation (2); Low correlation (1), No correlation

GRAPHIC ERA (DEEMED TO BE UNIVERSITY), DEHRADUN

SEMESTER VII

Name of Department: - Computer Science and Engineering

1.	Subject Code:	TCS 763	Course Title:	Social and Web Analytics			
2.	Contact Hours:	L: 3	T: 1	P: 0			
3.	Examination Duration (Hrs):	Theory		4	Practical		
4.	Relative Weight:	CIE	25	MSE	25	ESE	50
5.	Credits:	3					
6.	Semester:	VII					
7.	Category of Course:	DSE					
8.	Pre-requisite:	(TCS 341) Python programming, (TCS 462) Introduction to Big Data					

9. Course Outcome:	After completion of the course the students will be able to: CO1: Understand social media, web and social media analytics, and their potential impact. CO2: Identify key performance indicators for a given goal, identify data relating to the metrics and key performance indicators. CO3: Design and analyze understand usability metrics, web, and social media metrics. CO4: Use ready-made web analytics tools (Google Analytics) CO5: Understand a statistical programming language (R) and use its graphical development environment (Deduce) for data exploration and analysis. CO6: Create web analytics solutions for Real World Problems
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10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	Unit 1: Web and social media (Web sites, web apps, mobile apps and social media), Usability, user experience, customer experience, customer sentiments, web marketing, conversion rates, ROI, brand reputation, competitive advantages , Web analytics and a Web analytics 2.0 framework (clickstream, multiple outcomes analysis, experimentation and testing, voice of customer, competitive intelligence, Insights)	8
2	Unit 2: Data (Structured data, unstructured data, metadata, Big Data and Linked Data), Lab testing and experiment design (selecting participants, within-subjects or between subjects' study, counter balancing, independent and dependent variable; A/B testing, multivariate testing, controlled experiments) Data analysis basics (types of data, metrics and data, descriptive statistics, comparing means, correlations, nonparametric tests, presenting data graphically)	10
3	Unit 3: Measuring user experience - Usability metrics (performance metrics, issues-based metrics, self-reported metrics), Planning and performing a usability study (study goals, user goals, metrics and evaluation methods, participants, data collection, data analysis), Typical types of usability studies and their corresponding metrics (comparing alternative designs, comparing with competition, completing a task or transaction, evaluating the impact of subtle changes)	9
4	Unit 4: Web metrics and web analytics- PULSE metrics (Page views, Uptime, Latency, Seven-day active users) on business and technical issues; HEART metrics (Happiness, Engagement, Adoption, Retention, and Task success) on user behavior issues; On-site web analytics, off-site web analytics, the goal-signal-metric process.	9

5	Unit 5: Social media analytics – Introduction, Social media KPIs (reach and engagement), Performing social media analytics (business goal, KPIs, data gathering, analysis, measure and feedback), Data analysis language and tools: Ready-made tools for Web and social media analytics (Key Google Analytics metrics, Dashboard, social reports) Statistical programming language (R), its graphical development environment (Deducer) or data exploration and analysis, and its social media analysis packages	10
	Total	49

Text Books:

Authors Name	Title	Edition	Publisher, Country	Year
Avinash Kaushik	Web Analytics 2.0: The Art of Online Accountability and Science of Customer Centricity,	1 st	Sybex,Australia	2009
Matthew Ganis, Avinash Kohirkar	Social Media Analytics: Techniques and Insights for Extracting Business Value Out of Social Media	1 st	IBM Press, United States	2015

Reference Books:

Authors Name	Title	Edition	Publisher, Country	Year
Marshall Sponder	Social Media Analytics: Effective Tools for Building, Interpreting, and Using Metrics	1 st	McGraw Hill Education, American	2014

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
TCS763.1	Understand social media, web and social media analytics, and their potential impact.	2	2						2							1
TCS763.2	Identify key performance indicators for a given goal, identify data relating to the metrics and key performance indicators.	2	3	2	1	1			1	1	2		1		2	2
TCS763.3	Design and analyze understand usability metrics, web, and social media metrics.	1			2	1			2		1		1			2
TCS763.4	Use ready-made web analytics tools (Google Analytics)		2		2	3			2	1	2		1		2	1
TCS763.5	Understand a statistical programming language (R) and use its graphical development environment (Deduce) for data exploration and analysis.	1	2	1		1			1				2			
TCS763.6	Create web analytics solutions for Real World Problems	1			2	2			2	2	3	1	1		2	2
TCS 763		1.40	2.25	1.50	1.75	1.60	-	-	1.67	1.33	2.00	1.00	1.20	-	2.00	1.60

High correlation (3); Medium correlation (2); Low correlation (1), No correlation (-)

GRAPHIC ERA (DEEMED TO BE UNIVERSITY), DEHRADUN

SEMESTER VIII

Name of Department: - Computer Science and Engineering

1.	Subject Code:	TCS 862	Course Title:	FATE in AI
2.	Contact Hours:	L: 3	T: 1	P: 0
3.	Examination Duration (Hrs):	Theory 4	Practical 0	
4.	Relative Weight:	CIE 25	MSE 25	ESE 50
5.	Credits:	3		
6.	Semester:	VIII		
7.	Category of Course:	DSE		
8.	Pre-requisite:	(TCS 562) Introduction to Artificial Intelligence and Data Science		

9. Course Outcome:	After completion of the course the students will be able to: CO1: Apply Fairness in designing AI algorithms. CO2: Understand and Examine Accountability in AI CO3: Understand and Examine pitfalls of various contemporary AI applications. CO4: Analyze the ethics for designing future AI systems. CO5: Evaluate fairness and transparency of AI systems. CO6: Examine Real World Cases from policy perspectives
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10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	Unit 1: Data: Protection rational & genesis, data protection in India (judicial developments on right to privacy, legislative developments); Territorial and Personal Scope; Personal data; Sensitive personal data; Processing of data; Processing of sensitive data; Rights: Introduction, right to object to processing, right to be forget; Case studies.	8
2	Unit 2: Fairness: Introduction, sources of unfairness, definitions; Metrics for fairness, fair data; pre-processing methods; In-processing methods;	10

	post-processing methods; Model auditing for fairness; ML models and privacy; ML models and security; Fair product design & development; Laws for ML; Compliance tools: Anonymization, Privacy by design.	
3	Unit 3: Accountability & Ethics: Introduction, Guidelines in AI ethics; AI in practice; Advances in AI ethics;	8
4	Unit 4: Transparency (Explainability): Importance of explainability in AI systems, Case studies; Accuracy-interpretability tradeoff in machine learning; Different types of interpretability approaches: Rule-based, Prototype-based, Feature importance-based, post-hoc explanations.	10
5	Unit 5: FATE incorporation in AI designing systems, Issues, Effectiveness, Responsible AI, Algorithm Inclusivity and Accessibility, Real World use case examination.	12
	Total	48

Text Books:

Authors Name	Title	Edition	Publisher, Country	Year
Aileen Nielsen	Practical Fairness: Achieving Fair and Secure Data Models	1 st	O'Reilly,United Kingdom	2021
Solon Barcas, Moritz Hardt, Arvind Narayanan	Fairness And Machine Learning Limitations and Opportunities	1 st	MIT Press,United States	2019

Reference Books:

Authors Name	Title	Edition	Publisher, Country	Year

Course Articulation Matrix

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
TCS862.1	Apply Fairness in designing AI algorithms.	3	1	1			1						2		2	1
TCS862.2	Understand and Examine Accountability in AI	2	3	2	1	1			1	1	2		1		2	2
TCS862.3	Understand and Examine pitfalls of various contemporary AI applications.	2	1		2	1			1		1		2		1	2
TCS862.4	Analyze the ethics for designing future AI systems.		2		2	3			2	1	2		1		2	1
TCS862.5	Evaluate fairness and transparency of AI systems.	1	2	1		1			1				2			
TCS862.6	Examine Real World Cases from policy perspectives	1			2	2			2	2	3	1	1		2	2
TCS 862		1.80	1.80	1.33	1.75	1.60	1.00	-	1.40	1.33	2.00	1.00	1.50	-	1.80	1.60

High correlation (3); Medium correlation (2); Low correlation (1), No correlation (-)

GRAPHIC ERA (DEEMED TO BE UNIVERSITY), DEHRADUN

SEMESTER VIII

Name of Department: - Computer Science and Engineering

1.	Subject Code:	TCS 841	Course Title:	Quantum Computing
2.	Contact Hours:	L: 3	T: 1	P: 0
3.	Examination Duration (Hrs):	Theory 4	Practical 0	
4.	Relative Weight:	CIE 25	MSE 25	ESE 50
5.	Credits:	3		
6.	Semester:	VIII		
7.	Category of Course:	DSE		
8.	Pre-requisite:	(TCS 562) Introduction to Artificial Intelligence and Data Science		

9. Course Outcome:	After completion of the course the students will be able to: CO1: Understand the principles of quantum computation. CO2: Learn the circuit and gates involved in quantum computing. CO3: Understand the algorithms used in quantum computing. CO4: Study the information theory aspects of quantum computing. CO5: Use and build Quantum algorithms for solving various problems.
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10. Details of the Course:

Sl. No.	Contents	Contact Hours
1	Unit 1: Introduction: Overview of classical computing and its limitations; Introduction to quantum mechanics and quantum information theory; Quantum bits; Bloch sphere representation of a qubit; multiple qubits; Dirac notation; Hilbert space; Probabilities and	10

	measurements; Density operators and correlation; Quantum Parallelism; Entanglement and Superposition.	
2	Unit 2: Quantum Gates and Circuits: Quantum circuit representation; Quantum Logic Gates; Unitary Transformation; Hadamard Gate; Controlled Quantum Gates; Universal Quantum Gates; Special 2-Qubit Gates (CSIGN; SWAP α ; iSWAP; Berkeley B); Quantum measurements and observables	8
3	Unit 3: Quantum Algorithms: Relationship between classical and quantum algorithms; Classical computation on quantum computers; Relationship between quantum and classical complexity classes; Deutsch's algorithm, Deutsch-Jozsa algorithm; Shor factorization algorithm; Grover search algorithm; Quantum Approximate optimization algorithm (QAOA).	10
4	Unit 4: Quantum Information Theory: Entropy and information; Shannon entropy; Basic properties of entropy; Von Neumann entropy; Physical realisation; Harmonic oscillator quantum computer; Quantum teleportation and superdense coding; Quantum noise and quantum operations; Markov process; Data compression; Quantum error corrections; 3 Qubit phase flip code; Fault tolerant quantum computation; Quantum cryptography.	12
5	Unit 5: Qiskit Programming: Introduction and IBM Quantum Perspective; Qiskit software; Quantum gates and operations in Qiskit; Quantum measurement and simulation in qiskit; Quantum teleportation with qiskit; Implementation of Grover algorithm qiskit.	8
	Total	48

Text Books:

Authors Name	Title	Edition	Publisher, Country	Year
Nielsen, M., & Chuang, I	Quantum Computation and Quantum Information	10 th	Cambridge University Press, Kingdom of England	2010
John Gribbin	Computing with Quantum Cats: From Colossus to Qubits	1 st	Prometheus Books, Netherlands	2014
Eleanor G. Rieffel and Wolfgang H. Polak	Quantum Computing: A Gentle Introduction	1 st	MIT Press, United States	2011
Quantum information Theory	Mark M. Wilde	1 st	Cambridge University Press, Kingdom of England	2013

Reference Books:

Authors Name	Title	Edition	Publisher, Country	Year
D. A. Lidar & T. A. Brun	Quantum error correction	1 st	Cambridge University Press, Kingdom of England	2013
Mikio Nakahara and Tetsuo Ohmi	Quantum Computing: From Linear Algebra to Physical Realizations	1 st	CRC Press, United States	2008

CO	Statement	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
TCS841.1	Understand the principles of quantum computation.	-	3	-	-	1	1	-	1	1	1	1	-	2	-	1
TCS841.2	Learn the circuit and gates involved in quantum computing.	1	3	-	1	1	1	-	-	1	-	1	-	2	-	1
TCS841.3	Understand the algorithms used in quantum computing.	1	-	-	-	-	-	1	-	1	1	-	-	-	1	1
TCS841.4	Study the information theory aspects of quantum computing.	1	-	-	-	2	1	-	1	1	-	1	-	1	2	1
TCS841.5	Use and build Quantum algorithms for solving various problems.	1	2	3	-	2	-	1	1	2	-	2	2	3	2	1
TCS 862		1.00	2.67	3.00	1.00	1.50	1.00	1.00	1.00	1.20	1.00	1.25	2.00	2.00	1.67	1.00

High correlation (3); Medium correlation (2); Low correlation (1), No correlation (-)

2023-24 and 2024-25 onwards