Bachelor of Science in Data Science Program

For Fall 2022 and onwards

Department of Creative Technology

Faculty of Computing and Data Science

Air University, Islamabad

1 Structure of the Proposed Program

1.1 *Degree Title*

The title of degree is **"Bachelor of Science in Data Science"**

1.2 *Duration*

The **minimum duration** for completion of BS degree is four years and **maximum period of seven years** to complete BS degree requirements.

1.3 *Award of degree*

For the award of BS (Data Science) degree, a student must have:

- Passed courses with at least 131 credit hours, including all those courses that have been specified as core courses.
- Obtained CGPA of at least 2.00.

2 PROGRAMME GENERAL INFORMATION

Academic year	2022
Awarding body	Air University
Teaching institute and location	Air University, Islamabad Campus
Language of study	English
Final award	BS
Program title	Data Science
Duration of study	4 years (maximum time upto 6 years)
Total number of semesters	8
Number of weeks per semester	16 - 18 (16 for teaching and 2 for examinations)
Total number of credit hours	130
Total number of courses	42
Credit hours per semester	12-18
Starting date	Fall 2022 Semester

2.1 *Distribution of Courses*

Following is the distribution of courses:

#	Category	Credit Hours	No of Courses	HEC/NCEAC Cr Hrs.	HEC/NCEAC num. of Courses
1	Computing Core	39	11	39	11
2	DS Core	18	6	18	6
3	DS Electives	12	4	12	4
4	DS Supporting/Computer Science Core	18	5	18	5
5	Mathematical & Science Foundation	12	4	12	4
6	University Elective Courses	12	5	12	4
7	General Education Courses	19	7	19	7
	Total Credit Hours	130	42	130	41

2.2 Computing Core Courses

S.No.	Course Code	Course Title	Credit hours
1	CS111	Programming Fundamentals	(3-1-4)
2	CS112	Object Oriented Programming	(3-1-4)
3	CS214	Data Structures & Algorithms	(3-1-4)
4	MA216	Discrete Structures	(3-0-3)
5	CS225	Operating Systems	(3-1-4)
6	CS230	Database Systems	(3-1-4)
7	SE100	Software Engineering	(3-0-3)
8	CS360	Computer Networks	(3-1-4)
9	CY406	Information Security	(3-0-3)
10-11	DS499	Final Year Project	(0-6-6)
		Total	**(27-12-39)**

2.3 General Education Electives

S.No.	Course Code	Course Title	Credit hours
1	CS180	Intro to Info. & Comm. Technologies	(2-1-3)
2	EL XXX	English Composition & Comprehension	(3-0-3)
3	EL200	Communication & Presentation Skills	(3-0-3)
4	EL400	Technical & Business Writing	(3-0-3)

5	HU124	Islamic Studies and Ethics	(2-0-2)
6	HU125	Pakistan Studies & Global perspectives	(2-0-2)
7	CS270	Professional Practices	(3-0-3)
		Total	**(18-1-19)**

2.4 University Elective Courses

(Not limited to the list below, the University may add more courses)

Course Code	Course Title	Credit hours
BA356	Entrepreneurship	(3-0-3)
BA157	Management information systems	(3-0-3)
BA151	Principles of Management	(3-0-3)
BA241	Principles of Marketing	(3-0-3)
HU313	Industrial Psychology	(3-0-3)
EL300	Interpersonal skills/Public relations	(3-0-3)
HU214	Introduction to sociology	(3-0-3)
FL200	Arabic Language	(3-0-3)
FL201	French Language	(3-0-3)
FL202	Chinese Language	(3-0-3)
HU414	Social Service	(1-0-1)
Total		**(12-0-12)**

2.5 Mathematics and Science Foundation Courses

Course Code	Course Title	Credit hours
MA110	Calculus & Analytical Geometry	(3-0-3)
MA106	Differential Equations	(3-0-3)
MA201	Linear Algebra	(3-0-3)
MA301	Probability & Statistics	(3-0-3)
Total		**(12-0-12)**

2.6 Data Science Core Courses

Course Code	Course Title	Credit hours
DS211	Applied Statistics	(3-0-3)
DS110	Introduction to Data Science	(2-1-3)
DS460	Data Visualization	(2-1-3)
DS300	Data Warehousing & Business Intelligence	(2-1-3)
DS320	Big Data Analytics	(2-1-3)
DS312	Data Mining	(2-1-3)
Total		**(13-5-18)**

2.7 Data Science Supporting Courses/CS Core Courses

Course Code	Course Title	Credit hours
DS250	Artificial Intelligence	(3-1-4)
EE223	Digital Logic Design	(3-1-4)
CS332	Design & Analysis of Algorithms	(3-0-3)
CS223	Computer Organization & Assembly Language	(3-1-4)
CS426	Parallel & Distributed Computing	(2-1-3)
Total		**(14-4-18)**

2.8 Data Science Elective Courses

(More Courses may be added to this list)

Course Code	Course Title	Credit hours
DS301	Knowledge Representation & Reasoning	(3-0-3)
DS350	Digital image processing	(3-0-3)
DS351	Natural Language Processing	(3-0-3)
DS321	Semantic Computing	(3-0-3)
DS352	Machine Learning	(3-0-3)
DS470	Speech Processing	(3-0-3)
AI412	Fuzzy Systems	(3-0-3)
AI417	Swarm Intelligence	(3-0-3)
AI423	Information Retrieval	(3-0-3)
AI435	Reinforcement Learning	(3-0-3)
DS240	Knowledge Based Systems	(3-0-3)
DS255	Fundamentals of Computer Vision	(3-0-3)
DS301	Data Privacy	(3-0-3)
DS313	Survival Analysis	(3-0-3)
DS314	Actuarial Statistics	(3-0-3)
DS315	Multivariate Statistics and Reliability Analysis	(3-0-3)
DS353	Artificial neural Networks	(3-0-3)
DS340	Business Process Analysis	(3-0-3)
DS416	Bayesian Data Analysis	(3-0-3)
DS417	Spatial Statistics with Geographic Information Systems	(3-0-3)
DS421	Cloud Computing	(3-0-3)
DS451	Text Mining	(3-0-3)
DS455	Deep Learning	(3-0-3)
DS471	Time Series Analysis	(3-0-3)
DS476	Knowledge Graphs	(3-0-3)
DS478	Evolutionary Computing	(3-0-3)
MA221	Numerical Analysis & Computation	(2-0-2)
MA221L	Numerical Analysis & Computation Lab	(0-1-1)

MA478	Graph Theory	(3-0-3)
SE372	Theory of Automata & Formal Languages	(3-0-3)
Total (Any Four of the Above)		**(12-0-12)**

2.9 *Semester Plan*

Semester - I

Code	Course Title	Non-medical Credit Hours	Medical Credit hours	Prerequisite
CS180	Introduction to Info. & Comm. Technologies	(2-0-2)	(2-0-2)	
CS180L	Introduction to Info. & Comm. Technologies Lab	(0-1-1)	(0-1-1)	
CS111	Programming Fundamentals	(3-0-3)	(3-0-3)	
CS111L	Programming Fundamentals Lab	(0-1-1)	(0-1-1)	
EL 100	Reading and Writing Skills	(3-0-3)	(3-0-3)	
HU124	Islamic Studies and Ethics	(2-0-2)	(2-0-2)	
MA113	Pre-Calculus	N/A	(2-0-2)	
MA114	Foundational Mathematics	N/A	(4-0-4)	
Total		(10-2-12)	(16-2-18)	

Semester - II

Code	Course Title	Credit Hours	Prerequisite
EE223	Digital Logic Design	(3-0-3)	
EE223L	Digital Logic Design Lab	(0-1-1)	
CS112	Object Oriented Programming	(3-0-3)	CS 111, CS111L
CS112L	Object Oriented Programming Lab	(0-1-1)	CS 111
EL200	Communication & Presentation Skills	(3-0-3)	EL100
MA110	Calculus & Analytical Geometry	(3-0-3)	
MA216	Discrete Structure	(3-0-3)	
Total		(15-2-17)	

Semester - III

Code	Course Title	Credit Hours	Prerequisite
CS214	Data Structures & Algorithms	(3-0-3)	CS112, CS112L
CS214L	Data Structures & Algorithms Lab	(0-1-1)	CS112
CS 223	Computer Organization & Assembly Language	(3-0-3)	EE223, EE223L

CS 223L	Computer Organization & Assembly Language Lab	(0-1-1)	EE223
MA106	Differential Equations	(3-0-3)	MA110
DS210	Introduction to Data Science	(2-0-2)	CS112, CS112L
DS210L	Introduction to Data Science Lab	(0-1-1)	CS112
MA301	Probability & Statistics	(3-0-3)	
Total		(14-3-17)	

Semester - IV

Code	Course Title	Credit Hours	Prerequisite
CS230	Database Systems	(3-0-3)	CS 214,CS214L
CS230L	Database Systems Lab	(0-1-1)	CS 214
CS 332	Design and Analysis of Algorithms	(3-0-3)	CS 214,CS214L
CS360	Computer Networks	(3-0-3)	
CS360L	Computer Networks Lab	(0-1-1)	
MA201	Linear Algebra	(3-0-3)	MA110
DS250	Artificial Intelligence	(3-0-3)	
DS250L	Artificial Intelligence Lab	(0-1-1)	
Total		(15-3-18)	

Semester - V

Code	Course Title	Credit Hours	Prerequisite
DS311	Applied Statistics	(2-1-3)	MA301
DS300	Data Warehousing & Business Intel.	(2-0-2)	DS210, DS210L
DS300L	Data Warehousing & Business Intel. Lab	(0-1-1)	DS210
DS312	Data Mining	(2-0-2)	DS250, DS250L
DS312L	Data Mining Lab	(0-1-1)	DS250
DSXXX	DS Elective-1	(3-0-3)	
DSXXX	DS Elective-2	(3-0-3)	
HU/BAXXX	University Elective - 1	(3-0-3)	
Total		(16-2-18)	

Semester - VI

Code	Course Title	Credit Hours	Prerequisite
CS225	Operating System	(3-0-3)	CS 214,CS214L
CS225L	Operating System Lab	(0-1-1)	CS 214
SE100	Software Engineering	(3-0-3)	
DSXXX	DS Elective-3	(3-0-3)	
EL400	Technical & Business Writing	(3-0-3)	EL200
DS497	Final Year Project -I	(0-1-1)	List A
DS320	Big Data Analytics	(2-0-2)	DS210, DS210L
DS320L	Big Data Analytics Lab	(0-1-1)	DS210
Total		(14-3-17)	

Semester - VII

Code	Course Title	Credit Hours	Prerequisite
DS498	Final Year Project - II	(0-2-2)	DS497
HU/BAXXX	University Elective - 1	(3-0-3)	
CY406	Information Security	(3-0-3)	
DS315	DS Elective-4(Multivariate Statistics and Reliability Analysis)	(3-0-3)	
CS426	Parallel & Distributed Computing	(2-0-2)	CS225, CS225L
CS426L	Parallel & Distributed Computing Lab	(0-1-1)	CS225
DS460	Data Visualization	(2-0-2)	DS300, DS300L
DS460L	Data Visualization Lab	(0-1-1)	DS300
Total		(13-4-17)	

Semester - VIII

Code	Course Title	Credit Hours	Prerequisite
DS499	Final Year Project - III	(0-3-3)	DS498
HU414	Social Services	(1-0-1)	
HU/BAXXX	University Elective-3	(3-0-3)	
HU/BAXXX	University Elective-4	(2-0-2)	
CS270	Professional Practices	(3-0-3)	
HU125	Pakistan Studies & Global perspectives	(2-0-2)	
Total		(11-3-14)	
Total Credit Hours = 130		130	

For Fall 2022 and onwards

List A

Code	Course Title	Credit Hours	Prerequisite
CS214	Data Structures & Algorithms	(3-0-3)	CS112, CS112L
CS214L	Data Structures & Algorithms Lab	(0-1-1)	CS112
DS210	Introduction to Data Science	(2-0-2)	CS112, CS112L
DS210L	Introduction to Data Science Lab	(0-1-1)	CS112

3 References

[1]	"Data Science Platform PR News," 2020. [Online]. Available: https://www.prnewswire.com/news-releases/data-science-platform-market-size-is-projected-to-grow-usd-107-640-11-million-by-2025--valuates-reports-301130085.html#:~:text=The%20Global%20Data%20Science%20Platform,19.39%25%20during%20the%20forecast%20period. [Accessed 19 November 2020].
[2]	"Market and Markets", [Online]. Available: https://www.marketsandmarkets.com/Market-Reports/data-science-platform-market-21532997.html [Accessed 19 November 2020].
[3]	"Gartner," [Online]. Available: https://www.gartner.com/doc/3471559?srcId=1-3931087981.
[4]	"Forbes," [Online]. Available: https://www.forbes.com/sites/louiscolumbus/2018/01/12/10-charts-that-will-change-your-perspective-on-artificial-intelligences-growth/#35c868764758.
[5]	"NorthEastern Data Science," [Online]. Available: https://www.northeastern.edu/graduate/blog/data-science-careers-shaping-our-future/#:~:text=For%20four%20years%20in%20a,in%20the%20field%20through%202026.

4 COURSES SYLLABUS

Data Science Core Courses:

Calculus & Analytical Geometry			
Credit Hours:	3 (3,0)	**Prerequisites:**	None

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Gain familiarity with elementary algebraic and transcendental functions which arise in computer science.	C	1
Relate the concepts of calculus of single variable to their graphical, numerical and symbolic representations.	C	2
Use differentiation to solve related rates and optimization problems which model real world situations.	C	3
Apply Fundamental Theorem of Calculus to calculate the area between the curves and volume of solids.	C	3
* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain		

Course Content:

Limits and Continuity; Introduction to functions, Introduction to limits, Techniques of funding limits, Indeterminate forms of limits, Continuous and discontinuous functions and their applications, Differential calculus; Concept and idea of differentiation, Geometrical and Physical meaning of derivatives, Rules of differentiation, Techniques of differentiation, Rates of change, Tangents and Normals lines, Chain rule, implicit differentiation, linear approximation, Applications of differentiation; Extreme value functions, Mean value theorems, Maxima and Minima of a function for single-variable, Concavity, Integral calculus; Concept and idea of Integration, Indefinite Integrals, Techniques of integration, Riemann sums and Definite Integrals, Applications of definite integrals, Improper integral, Applications of Integration; Area under the curve, Analytical Geometry; Straight lines in R3, Equations for planes.

Teaching Methodology:

Lecturing, Written Assignments

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Final Exam

Reference Materials:

1. Calculus and Analytic Geometry by Kenneth W. Thomas.
2. Calculus by Stewart, James.
3. Calculus by Earl William Swokowski; Michael Olinick; Dennis Pence; Jeffery A. Cole.

Linear Algebra			
Credit Hours:	3 (3,0)	**Prerequisites:**	Calculus & Analytical Geometry

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Understand the basic ideas of linear independence and solve system of linear equations	C	2
Apply the basic techniques of matrix algebra including finding the inverse of a matrix	C	3
Be **familiar** with the notion of linear transformation and concepts of dimension, rank and nullity	C	2
Find eigenvalues and eigenvectors of a matrix and understand inner product spaces	C	2

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Algebra of linear transformations and matrices. determinants, rank, systems of equations, vector spaces, orthogonal transformations, linear dependence, linear Independence and bases, eigenvalues and eigenvectors ,characteristic equations, Inner product space and quadratic forms

Teaching Methodology:

Lecturing, Written Assignments

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Final Exam

Reference Materials:

1. Elementary Linear Algebra by Howard Anton
2. Linear Algebra and its Applications by Gibert Strang

Probability & Statistics			
Credit Hours:	3 (3,0)	**Prerequisites:**	None

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Manipulate the data, calculate measure of Central Tendency, Location and measure of Dispersion and interpret the results	C	3
Understand uncertainty, model uncertain situations and find precise estimates using probability and its Laws	C	2
Understand Random Variables and discrete and continuous probability distributions and their properties.	C	2
Apply Continuous probability distributions in real life situations.	C	3

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Introduction to Statistics and Data Analysis, Statistical Inference, Samples, Populations, and the Role of Probability. Sampling Procedures. Discrete and Continuous Data. Statistical Modeling. Types of Statistical Studies. Probability: Sample Space, Events, Counting Sample Points, Probability of an Event, Additive Rules, Conditional Probability,

Independence, and the Product Rule, Bayes' Rule. Random Variables and Probability Distributions. Mathematical Expectation: Mean of a Random Variable, Variance and Covariance of Random Variables, Means and Variances of Linear Combinations of Random Variables, Chebyshev's Theorem. Discrete Probability Distributions. Continuous Probability Distributions. Fundamental Sampling Distributions and Data Descriptions: Random Sampling, Sampling Distributions, Sampling Distribution of Means and the Central Limit Theorem. Sampling Distribution of S2, t-Distribution, FQuantile and Probability Plots. Single Sample & One- and Two-Sample Estimation

Problems. Single Sample & One- and Two-Sample Tests of Hypotheses. The Use of PValues for Decision Making in Testing Hypotheses (Single Sample & One- and TwoSample Tests), Linear Regression and Correlation. Least Squares and the Fitted Model, Multiple Linear Regression and Certain, Nonlinear Regression Models, Linear Regression Model Using Matrices, Properties of the Least Squares Estimators.

Teaching Methodology:

Lecturing, Written Assignments, Presentation, Final Exam

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Report Writing, Presentation, Final Exam

Reference Materials:

1. Probability and Statistics for Engineers and Scientists by Ronald E. Walpole, Raymond H. Myers, Sharon L. Myers and Keying E. Ye, Pearson; 9th Edition (January 6, 2011). ISBN-10: 0321629116
2. Probability and Statistics for Engineers and Scientists by Anthony J. Hayter, Duxbury Press; 3rd Edition (February 3, 2006), ISBN-10:0495107573
3. Schaum's Outline of Probability and Statistics, by John Schiller, R. Alu Srinivasan and Murray Spiegel, McGraw-Hill; 3rd Edition (2008). ISBN-10:0071544259

Introduction to Data Science			
Credit Hours:	3(2,1)	**Prerequisites:**	Object Oriented Programming

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Understand key components in the field of Data Science	C	2
Implement classical Data Science techniques	C	3
Analyze Data Science techniques for practical problem solving	C	4

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Introduction (Introduction, basic component of AI, Identifying AI systems, branches of AI, etc.); Reasoning and Knowledge Representation (Introduction to Reasoning and Knowledge Representation, Propositional Logic, First order Logic); Problem Solving by Searching (Informed searching, Uninformed searching, Local searching.); Constraint
Satisfaction Problems; Adversarial Search (Min-max algorithm, Alpha beta pruning, Game-playing); Learning (Unsupervised learning, Supervised learning, Reinforcement learning) ;Uncertainty handling (Uncertainty in AI, Fuzzy logic); Recent trends in AI and applications of AI algorithms (trends, Case study of AI systems, Analysis of AI systems)

Teaching Methodology:

Lectures, Assignments, labs, Projects, Presentations, etc. Major component of the course should be covered using conventional lectures. Practical contact hours are compulsory (~45 hours in a semester).

Course Assessment:

Exams, Assignments, Quizzes, Project, Presentations. Course will be assessed using a combination of written examinations and project(s). Practical evaluation, using rubrics, is encouraged and suggested to make up around 20% of the course.

Reference Materials:

1. Stuart Russell and Peter Norvig, Data Science. A Modern Approach, 3rd edition, Prentice Hall, Inc., 2010.
2. Hart, P.E., Stork, D.G. and Duda, R.O., 2001. Pattern classification. John Willey & Sons.
3. Luger, G.F. and Stubblefield, W.A., 2009. AI algorithms, data structures, and idioms in Prolog, Lisp, and Java. Pearson Addison-Wesley.

Machine Learning			
Credit Hours:	(3,0)	**Prerequisites:**	None

Course Learning Outcomes (CLOs):		
The core objectives of this course are	**Domain**	**BT Level***
* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain		

Course Contents:

Introduction to machine learning and statistical pattern recognition. Supervised learning: Part I (Graphical models (full Bayes, Naïve Bayes), Decision trees for classification & regression for both categorical & numerical data, Ensemble methods, Random forests, Boosting (Adaboost and Xgboost), Stacking; Part II (Four Components of Machine Learning Algorithm (Hypothesis, Loss Functions, Derivatives and Optimization Algorithms), Gradient Descent, Stochastic Gradient Descent, Linear Regression, Nonlinear Regression, Perceptron, Support vector machines, Kernel Methods, Logistic
Regression, Softmax, Neural networks); Unsupervised learning: K-means, Density Based Clustering Methods (DBSCAN, etc.), Gaussian mixture models, EM algorithm, etc.; Reinforcement learning; Tuning model complexity; Bias-Variance Tradeoff; Grid Search, Random Search; Evaluation Metrics; Reporting predictive performance

Teaching Methodology:

Lectures, Problem based learning

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Presentations, Final Exam

Reference Material:

Books

1. Elements of Statistical Learning
2. Pattern Recognition & Machine Learning, 1st Edition, Chris Bishop
3. Machine Learning: A Probabilistic Perspective, 1st Edition, Kevin R Murphy
4. Applied Machine Learning, online Edition, David Forsyth

Knowledge Representation & Reasoning			
Credit Hours:	(3,0)	**Prerequisites:**	None

Course Learning Outcomes (CLOs):		
The core objectives of this course are	**Domain**	**BT Level***
Understand the fundamentals of knowledge representation and reasoning in deterministic situations	C	2
Understand the challenges in representing knowledge and reasoning under uncertainty	C	2
Analyze different situations and apply appropriate knowledge representation frameworks	C	4
Development of hybrid approaches by synergizing the existing framework to solve complex decision-making problems.	C	4

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Contents:

General knowledge representation issues; motivating applications (medical, legal, business); overview of first-order logic. First-order logic, continued; developing ontologies; limitations of first-order logic (lack of expressivity, lack of inferential power); knowledge engineering issues. Reasoning about time; temporal logics; introduction to modal logics. Modal logics of knowledge and belief; possible-world semantics; deontic logics for legal reasoning. Syntactic logics of knowledge and belief; quotations, paradoxes, and resolutions; planning; knowledge and planning. Semantic networks; description logics; standard inheritance; inheritance tools and applications. Default and nonmonotonic logics; closed-world assumption; circumscription; belief revision. Nonmonotonic inheritance networks; algorithms. Formula-augmented networks; applications to medical reasoning and the insurance industry. Frame languages; Bayesian networks. Production systems, expert systems. Multiple-level knowledge representations (e.g., combining semantic and Bayesian networks); formal and informal mappings between different knowledge representations. Open issues in knowledge representation.

Teaching Methodology:

Lectures, Problem based learning

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Presentations, Final Exam

Reference Material:

Books

1. Stuard Russell and Peter Norvig, Artificial Intelligence: A Modern Approach (3rd Ed.) (2015)
2. David Poole and Alan Mackworth, Artificial Intelligence: Foundations of Computational Agents, 2nd Ed, 2017
3. Ronald Brachman and Hector Levesque. Knowledge Representation and Reasoning, 2004

Natural Language Processing			
Credit Hours:	3(3,0)	**Prerequisites:**	

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Identify techniques for information retrieval, language translation, and text classification.	C	1
List the advantages of using standard corpora. Identify examples of current corpora for a variety of NLP tasks.	C	2
Define and contrast deterministic and stochastic grammars, providing examples to show the adequacy of each.	C	3
Simulate, apply, or implement classic and stochastic algorithms for parsing natural language.	C	4

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Deterministic and stochastic grammars, Parsing algorithms, CFGs, Representing meaning / Semantics, Semantic roles, Temporal representations, Corpus-based methods, N-grams and HMMs, Smoothing and backoff, POS tagging and morphology, Information retrieval, Vector space model, Precision and recall, Information extraction, Language translation, Text classification, categorization, Bag of words model.

Teaching Methodology:

Lecturing, Written Assignments, Project, Report Writing

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Presentations, Final Exam

Reference Materials:

1. Python Machine Learning, Sebastian Raschka. Publisher: Packt Publishing, 2015.
2. Natural Language Processing with Python: Analyzing Text with the Natural Language Toolkit Latest Edition, Steven Bird, Ewan Klein and Edward Loper Publisher: O'Reilly Media, 2009.
3. Speech and Language Processing, Latest Edition, Daniel Jurafsky and James H. Martin Publisher: Prentice Hall, 2000.

Fundamentals of Computer Vision			
Credit Hours:	(3,0)	**Prerequisites:**	None

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
1. Understand and explain the field of computer vision in general for different applications, etc.	C	1,2
2. Understand and implement camera calibration	C	1,2,3
3. Work under OpenCV or Matlab computer vision toolbox, etc.	C	1,2,3
4. Implement an algorithm to assemble the extracted features to develop a higher-level perception	C	3,6
5. Implement different algorithms for spatial and frequency domain filtering, feature detection, structure from motion, motion estimation, etc.	C	3
6. To detect, recognize and track different types of the objects in the scene	C	3,6
7. Develop an algorithm for context awareness or scene understanding	C	3,6

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Introduction, Image formation, Spatial and frequency domain processing, Feature detection and extraction, Image registration, Segmentation, Camera calibration, Structure from motion, Motion estimation, Stereo vision, Object detection and recognition, Object tracking, 3D scene reconstruction, Context and scene understanding, Image stitching, Image-based and video-based rendering, High-performance computing paradigms for vision and image processing.,

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. Computer Vision - A Modern Approach, by D. Forsyth and J. Ponce, Prentice Hall, 2003.
2. Szeliski R., Computer Vision - Algorithms and Applications, Springer, 2011.
3. J. R. Parker, Algorithms for Image Processing and Computer Vision, Willey Publishing Inc. 2011.
4. Gonzalez R. C., Woods R. E., Digital Image Processing, Pearson Education, 3rd edition, 2008.

Programming Fundamentals			
Credit Hours:	4(3,1)	**Prerequisites:**	None

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Understand basic problem solving steps and logic Constructs	C	2
Apply basic programing concepts	C	3
Design and **implement** algorithms to solve real world problems	C	3

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

This course covers overview of Computer Programming, Principles of Structured and Modular Programming, Overview of Structured Programming Languages, Algorithms and Problem Solving, Program Development: Analyzing Problem, Designing Algorithm/Solution, Testing Designed Solution, Translating Algorithms into Programs, Fundamental Programming Constructs, Data Types; Basics of Input and Output, Selection and Decision (If, If-Else, Nested If-Else, Switch Statement and Condition Operator), Repetition (While and For Loop, Do-While Loops), Break Statement, Continue Statement, Control Structures, Functions, Arrays, Pointers, Records, Files (Input-Output), Testing & Debugging.

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. Programming in C, Stephen G. Kochan, Addison-Wesley Professional, 4th edition, 2013.
2. C++ How to Programme, Paul Deitel and Harvey Deitel, Prentice Hall; 9thedition, 2013.
3. Object Oriented Programming in C++ by Robert Lafore
4. Problem Solving and Program Design in C++, 7th Edition by Jeri R. Hanly & Elliot B. Koffman

Object Oriented Programming

Credit Hours:	4(3,1)	Prerequisites:	Programming Fundamentals

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	Domain	BT Level*
Understand principles of object-oriented paradigm.	C	2
Identify the objects & their relationships to build object oriented solution	C	3
Model a solution for a given problem using object oriented principles	C	3
Examine an object oriented solution	C	4

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Introduction to object oriented design, history and advantages of object oriented design, introduction to object oriented programming concepts, classes, objects, data encapsulation, constructors, destructors, access modifiers, const vs non-const functions, static data members & functions, function overloading, operator overloading, identification of classes and their relationships, composition, aggregation, inheritance, multiple inheritance, polymorphism, abstract classes and interfaces, generic programming concepts, function & class templates, standard template library, object streams, data and object serialization using object streams, exception handling.

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. Starting Out with C++ from Control Structures to Objects, 9th Edition, Tony Gaddis
2. C++ How to Program, 10th Edition, Deitel & Deitel.
3. Object Oriented Programming in C++, 3rd Edition by Robert Lafore
4. Java: How to Program, 9th Edition by Paul Deitel
5. Beginning Java 2, 7th Edition by Ivor Horton
6. An Introduction to Object Oriented Programming with Java, 5th Edition by C. Thomas Wu

Data Structures and Algorithms

Credit Hours:	4(3,1)	Prerequisites:	Object Oriented Programming

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	Domain	BT Level*
Implement various data structures and their algorithms and apply them in implementing simple applications	C	3
Analyze simple algorithms and determine their complexities.	C	5
Apply the knowledge of data structure to other application domains.	C	3
Design new data structures and algorithms to solve problems.	C	6

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Abstract data types, complexity analysis, Big O notation, Stacks (linked lists and array implementations), Recursion and analyzing recursive algorithms, divide and conquer algorithms, Sorting algorithms (selection, insertion, merge, quick, bubble, heap, shell, radix, bucket), queue, dequeuer, priority queues (linked and array implementations of queues), linked list & its various types, sorted linked list, searching an unsorted array, binary search for sorted arrays, hashing and indexing, open addressing and chaining, trees and tree traversals, binary search trees, heaps, M-way tress, balanced trees, graphs, breadth-first and depth-first traversal, topological order, shortest path, adjacency matrix and adjacency list implementations, memory management and garbage collection.

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. Data Structures and Algorithms in C++ by Adam Drozdek
2. Data Structures and Algorithm Analysis in Java by Mark A. Weiss
3. Data Structures and Abstractions with Java by Frank M. Carrano & Timothy M. Henry
4. Data Structures and Algorithm Analysis in C++ by Mark Allen Weiss
5. Java Software Structures: Designing and Using Data Structures by John Lewis and Joseph Chase

Discrete Structures			
Credit Hours:	3(3,0)	**Prerequisites:**	None

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Understand the key concepts of Discrete Structures such as Sets, Permutations, Relations, Graphs and Trees etc.	C	2
Apply formal logic proofs and/or informal, but rigorous, logical reasoning to real problems, such as predicting the behavior of software or solving problems such as puzzles.	C	3
Apply discrete structures into other computing problems such as formal specification, verification, databases, artificial intelligence, and cryptography.	C	3
Differentiate various discrete structures and their relevance within the context of computer science, in the areas of data structures and algorithms, in particular	C	4

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Mathematical reasoning, propositional and predicate logic, rules of inference, proof by induction, proof by contraposition, proof by contradiction, proof by implication, set theory, relations, equivalence relations and partitions, partial orderings, recurrence relations, functions, mappings, function composition, inverse functions, recursive functions, Number Theory, sequences, series, counting, inclusion and exclusion principle, pigeonhole principle, permutations and combinations. Algorithms, Searching and Sorting Algorithms, elements of graph theory, planar graphs, graph coloring, Graph Algorithms, euler graph, Hamiltonian path, rooted trees, traversals.

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. Discrete Mathematics and Its Applications, 7th edition by Kenneth H. Rosen
2. Discrete Mathematics with Applications, 4th Edition by Susanna S. Epp
3. Discrete Mathematics, 7th edition by Richard Johnson Baugh
4. Discrete Mathematical Structures, 4th edition by Kolman, Busby & Ross
5. Discrete and Combinatorial Mathematics: An Applied Introduction by Ralph P. Grimaldi
6. Logic and Discrete Mathematics: A Computer Science Perspective by Winifred
7. Grassman

Operating System			
Credit Hours:	3(3,1)	**Prerequisites:**	Data Structure and Algorithms

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Understand the characteristics of different structures of the Operating Systems and identify the core functions of the Operating Systems	C	2
Analyze and evaluate the algorithms of the core functions of the Operating Systems and explain the major performance issues with regard to the core functions	C	5
Demonstrate the knowledge in applying system software and tools available in modern operating systems.	C	3

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Operating systems basics, system calls, process concept and scheduling, inter-process communication, multithreaded programming, multithreading models, threading issues, process scheduling algorithms, thread scheduling, multiple-processor scheduling, synchronization, critical section, synchronization hardware, synchronization problems, deadlocks, detecting and recovering from deadlocks, memory management, swapping, contiguous memory allocation, segmentation & paging, virtual memory management, demand paging, thrashing, memory-mapped files, file systems, file concept, directory and disk structure, directory implementation, free space management, disk structure and scheduling, swap space management, system protection, virtual machines, operating system security

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. Operating Systems Concepts, 9th edition by Abraham Silberschatz
2. Modern Operating Systems, 4th edition by Andrew S. Tanenbaum
3. Operating Systems, Internals and Design Principles, 9th edition by William Stallings

Database Systems			
Credit Hours:	3(3,1)	**Prerequisites:**	None

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Explain fundamental database concepts	C	2
Design conceptual, logical and physical database schemas using different data models.	C	5
Identify functional dependencies and resolve database anomalies by normalizing database tables.	C	2
Use Structured Query Language (SQL) for database definition and manipulation in any DBMS	C	4

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Basic database concepts, Database approach vs. file based system, database architecture, three level schema architecture, data independence, relational data model, attributes, schemas, tuples, domains, relation instances, keys of relations, integrity constraints, relational algebra, selection, projection, Cartesian product, types of joins, normalization, functional dependencies, normal forms, entity relationship model, entity sets, attributes, relationship, entity-relationship diagrams, Structured Query Language (SQL), Joins and subqueries in SQL, Grouping and aggregation in SQL, concurrency control, database backup and recovery, indexes, NoSQL systems.

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. Database Systems: A Practical Approach to Design, Implementation, and Management, 6th Edition by Thomas Connolly and Carolyn Begg
2. Database Systems: The Complete Book, 2nd Edition by Hector Garcia-Molina, Jeffrey D. Ullman, Jennifer Widom
3. Database System Concepts, 6th Edition by Avi Silberschatz, Henry F. Korth and S. Sudarshan.
4. Database Management Systems, 3rd Edition by Raghu Ramakrishnan, Johannes Gehrke

Software Engineering			
Credit Hours:	3(3,0)	**Prerequisites:**	None

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Describe various software engineering processes and activates	C	1
Apply the system modeling techniques to model a medium size software systems	C	3
Apply software quality assurance and testing principles to medium size software systems	C	4
Discuss key principles and common methods for software project management such as scheduling, size estimation, cost estimation and risk analysis	C	2

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

What is Software Engineering? Software Lifecycle and Process Models, Software Engineering Tools and Programming Environments, Overview of Software Project Management, Software Requirements Specification, Software Design, Using APIs, Software Verification and Validation, and Software evolution, Software Engineering Tools for modeling such as: Enterprise Architect ,Visual Paradigm UML or Rational Rose will be covered in lab extensively covering flow-oriented modeling, behavioral modeling, scenario-base modeling and class modeling.

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. Software Engineering: A Practitioner's Approach by Roger Pressman, Published by McGraw-Hill Education, 2014.
2. Applying UML and Patterns: An Introduction to Object-Oriented Analysis and Design and Iterative Developmentby Craig Larman, 3rd Edition, Published by Pearson Education India, 2012.
3. Principles of CASE Tool Integration by Alan W. Brown, 1st Edition, 1994 Oxford University Press.
4. Computer Aided Software Engineering by Hausi A. Muller, Ronald J. Norman and Jacob Slonim, Springer, 1st Edition.

Computer Networks			
Credit Hours:	4(3,1)	**Prerequisites:**	None

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Describe the key terminologies and technologies of computer networks	C	2
Explain the services and functions provided by each layer in the Internet protocol stack.	C	2
Identify various internetworking devices and protocols and their functions in a networking	C	4
Analyze working and performance of key technologies, algorithms and protocols	C	4
Build Computer Network on various Topologies	P	3

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Basic concepts in computer communications and networks: access and core networks, circuit and packet switching, protocol layers, security. The Internet. Application Layer: application services and protocols, client-server and peer-to-peer models. Transport Layer: multiplexing and de-multiplexing, UDP, reliable transport and TCP, congestion control. Network Layer: virtual circuit and datagram packet switching, routers, IP protocols, routing algorithms, Internet routing protocols. Data Link Layer: error control, medium access control, link layer addressing, logical link control, link layer protocols. Local Area Networks: Ethernet, link layer switching. Wireless and mobile data networking. Multimedia application services and QoS. Introduction to data and network security.

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. Data Communications and Networking, by Behrouz A. Forouzan, McGraw-Hill Science; 5th edition.
2. Data and Computer Communications by William Stallings, Prentice Hall; 9th Edition.
3. Computer Networks by Andrew S. Tanenbaum and David J. Wetherall, Prentice Hall; 5th Edition.
4. Computer Networks and Internets by Douglas E. Comer, Prentice Hall; 5th Edition.

Information Security			
Credit Hours:	3(3,0)	**Prerequisites:**	None

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Explain key concepts of information security such as design principles, cryptography, risk management, and ethics	C	2
Discuss legal, ethical, and professional issues in information security	A	2
Apply various security and risk management tools for achieving information security and privacy	C	3
Identify appropriate techniques to tackle and solve problems in the discipline of information security	C	4

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Governance and security policy, threat and vulnerability management, incident management, risk management, information leakage, crisis management and business continuity, legal and compliance, security awareness and security implementation considerations. ISO 27000 series and the Plan-Do-Check-Act model, assessment of threats and vulnerabilities, incident response, forensics and investigations, risk assessment and risk management frameworks, dealing with classified/ sensitive data, contingency planning, legal and regulatory drivers and issues, certification, common criteria, security awareness, education and training, and practical considerations when implementing the frameworks to address current and future threats.

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. Information Security Management Handbook, Sixth Edition, Volume 6, edited by Harold F. Tipton, Micki Krause Nozaki, 2012
2. Management of Information Security by Michael E. Whitman, Herbert J. Mattord, Third Edition, 2010

Digital Logic Design			
Credit Hours:	4(3,1)	**Prerequisites:**	

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Acquire knowledge related to the concepts, tools and techniques for the design of digital electronic circuits	C	1
Demonstrate the skills to design and analyze both combinational and sequential circuits using a variety of techniques	C	4
Apply the acquired knowledge to simulate and implement small-scale digital circuits	P	3
Understand the relationship between abstract logic characterizations and practical electrical implementations.	C	2

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Number Systems, Logic Gates, Boolean Algebra, Combination logic circuits and designs, Simplification Methods (K-Map, Quinn Mc-Cluskey method), Flip Flops and Latches, Asynchronous and Synchronous circuits, Counters, Shift Registers, Counters, Triggered devices & its types. Binary Arithmetic and Arithmetic Circuits, Memory Elements, State Machines. Introduction Programmable Logic Devices (CPLD, FPGA) Lab Assignments using tools such as Verilog HDL/VHDL, MultiSim

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. Digital Fundamentals by Floyd, 11/e.
2. Fundamental of Digital Logic with Verilog Design, Stephen Brown, 2/e

Computer Organization and Assembly Language

Credit Hours:	4(3,1)	Prerequisites:	Digital Logic Design

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	Domain	BT Level*
Acquire the basic knowledge of computer organization computer architecture and assembly language	C	2
Understand the concepts of basic computer organization, architecture, and assembly language techniques	C	2
Solve the problems related to computer organization and assembly language	C	3

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Introduction to computer systems: Information is bits + context, programs are translated by other programs into different forms, it pays to understand how compilation systems work, processors read and interpret instructions stored in memory, caches matter, storage devices form a hierarchy, the operating system manages the hardware, systems communicate with other systems using networks; Representing and manipulating information: information storage, integer representations, integer arithmetic, floating point; Machine-level representation of programs: a historical perspective, program encodings, data formats, accessing information, arithmetic and logical operations, control, procedures, array allocation and access, heterogeneous data structures, putting it together: understanding pointers, life in the real world: using the gdb debugger, out of-bounds memory references and buffer overflow, x86-64: extending ia32 to 64 bits, machine-level representations of floating-point programs; Processor architecture: the Y86 instruction set architecture, logic design and the Hardware Control Language (HCL), sequential Y86 implementations, general principles of pipelining, pipelined Y86 implementations

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. Computer Systems: A Programmer's Perspective, 3/E (CS:APP3e), Randal E. Bryant and David R.O' Hallaron, Carnegie Mellon University
2. Robert Britton, MIPS Assembly Language Programming, Latest Edition,
3. Computer System Architecture, M. Morris Mano, Latest Edition,
4. Assembly Language Programming for Intel- Computer, Latest Edition

Parallel and Distributed Computing			
Credit Hours:	3(2,1)	**Prerequisites:**	Operating System

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Learn about parallel and distributed computers.	C	1
Write portable programs for parallel or distributed architectures using Message-Passing Interface (MPI) library	C	3
Analyze complex problems with shared memory programming with openMP.	C	4

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Asynchronous/synchronous computation/communication, concurrency control, fault tolerance, GPU architecture and programming, heterogeneity, interconnection topologies, load balancing, memory consistency model, memory hierarchies, Message passing interface (MPI), MIMD/SIMD, multithreaded programming, parallel algorithms & architectures, parallel I/O, performance analysis and tuning, power, programming models (data parallel, task parallel, process-centric, shared/distributed memory), scalability and performance studies, scheduling, storage systems, synchronization, and tools (Cuda, Swift, Globus, Condor, Amazon AWS, OpenStack, Cilk, gdb, threads, MPICH, OpenMP, Hadoop, FUSE).

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. Distributed Systems: Principles and Paradigms, A. S. Tanenbaum and M. V. Steen, Prentice Hall, 2nd Edition, 2007
2. Distributed and Cloud Computing: Clusters, Grids, Clouds, and the Future Internet, K Hwang, J Dongarra and GC. C. Fox, Elsevier, 1st Ed.

Analysis of Algorithms			
Credit Hours:	3(3,0)	**Prerequisites:**	Data Structures and Algorithms

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Explain what is meant by "best", "expected", and "worst" case behavior of an algorithm	C	2
Identify the characteristics of data and/or other conditions or assumptions that lead to different behaviors.	C	3
Determine informally the time and space complexity of simple algorithms List and contrast standard complexity classes	C	4
Use big O, Omega, Theta notation formally to give asymptotic upper bounds on time and space complexity of algorithms	C	4
Use of the strategies (brute-force, greedy, divide-and-conquer, and dynamic programming) to solve an appropriate problem	C	4
Solve problems using graph algorithms, including single-source and all-pairs shortest paths, and at least one minimum spanning tree algorithm	C	3
Trace and/or **implement** a string-matching algorithm	C	3

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Introduction; role of algorithms in computing, Analysis on nature of input and size of input Asymptotic notations; Big-O, Big Ω, Big Θ, little-o, little-ω, Sorting Algorithm analysis, loop invariants, Recursion and recurrence relations; Algorithm Design Techniques, Brute Force Approach, Divide-and-conquer approach; Merge, Quick Sort, Greedy approach; Dynamic programming; Elements of Dynamic Programming, Search trees; Heaps; Hashing; Graph algorithms, shortest paths, sparse graphs, String matching; Introduction to complexity classes.

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. Introduction to Algorithms (3rd edition) by Thomas H. Corman, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein
2. Algorithm Design, (1st edition, 2013/2014), Jon Kleinberg, Eva Tardos,
3. Algorithms, (4th edition, 2011), Robert Sedgewick, Kevin Wayne

Applied Statistics

Credit Hours:	3(3,0)	Prerequisites:	Probability and Statistics

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	Domain	BT Level*
Describe what part of statistics is meant for data scientist and what the applications of statistics in Data Science are.	C	1
Apply Statistical techniques in real life problems.	C	3
Analyze, Correlate, Forecast data by using different statistical techniques	C	2
Apply basic Data Science statistical techniques by using SPSS on real world datasets.	C	3

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Introduction to Statistics, Use of Statistics in Data Science, Experimental Design, Statistical Techniques for Forecasting, Interpolation/ Extrapolation, Introduction to Probability, Conditional Probability, Prior and Posterior Probability, Random number generation (RNG), Techniques for RNG, Correlation analysis, Chi Square Dependency tests, Diversity Index, Data Distributions Multivariate Distributions, Etechrror estimation, Confidence Intervals, Linear transformations, Gradient Descent and Coordinate Descent, Likelihood inference, Revision of linear regression and likelihood inference, Fitting algorithms for nonlinear models and related diagnostics, Generalized linear model; exponential families; variance and link functions, Proportion and binary responses; logistic regression, Count data and Poisson responses; log-linear models, Overdispersion and quasi-likelihood; estimating functions, Mixed models, random effects, generalized additive models and penalized regression; Introduction to SPSS, Probability/ Correlation analysis/ Dependency tests/ Regression in SPSS.

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. Probability and Statistics for Computer Scientists, 2nd Edition, Michael Baron.
2. Probability for Computer Scientists, online Edition, David Forsyth
3. Discovering Statistics using SPSS for Windows, Andy Field

Big Data Analytics			
Credit Hours:	3(2,1)	**Prerequisites:**	Introduction to Data Science

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Understand the fundamental concepts of Big Data and its programming paradigm.	C	2
Hadoop/MapReduce Programming, Framework, and Ecosystem	C	3
Apache Spark Programming	C	3

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Introduction and Overview of Big Data Systems; Platforms for Big Data, Hadoop as a Platform, Hadoop Distributed File Systems (HDFS), MapReduce Framework, Resource Management in the cluster (YARN), Apache Scala Basic, Apache Scala Advances, Resilient Distributed Datasets (RDD), Apache Spark, Apache Spark SQL, Data analytics on Hadoop / Spark, Machine learning on Hadoop / Spark, Spark Streaming, Other Components of Hadoop Ecosystem

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. White, Tom. "Hadoop: The definitive guide." O'Reilly Media, Inc., 2012.
2. Karau, Holden, Andy Konwinski, Patrick Wendell, and Matei Zaharia. "Learning spark: lightning-fast big data analysis." O'Reilly Media, Inc., 2015.
3. Miner, Donald, and Adam Shook. "MapReduce design patterns: building effective algorithms and analytics for Hadoop and other systems." O'Reilly Media, Inc., 2012.

Data Warehousing and Business Intelligence			
Credit Hours:	3(2,1)	**Prerequisites:**	Introduction to Data Science

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Demonstrate an appreciation of the role that Data Warehouses and Business Intelligence play in enhancing the decision-making process	C	2
Demonstrate an understanding of the fundamental concepts of the Star and the Snowflake Schema; learn how to design the schema of a DW based on these two models.	C	2
Understand the architecture of DW Systems and be able to specify the advantages and potential problem areas	C	3
Use Analytic SQL to aggregate, analyze and report, and model data.	C	4

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Introduction to Data Warehouse and Business Intelligence; Necessities and essentials of Business Intelligence; DW Life Cycle and Basic Architecture; DW Architecture in SQL Server; Logical Model; Indexes; Physical Model; Optimizations; OLAP Operations, Queries and Query Optimization; Building the DW; Data visualization and reporting based on Datawarehouse using SSAS and Tableau; Data visualization and reporting based on Cube; Reports and Dashboard management on PowerBI; Dashboard Enrichment; Business Intelligence Tools.

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. W. H. Inmon, "Building the Data Warehouse", Wiley-India Edition.
2. Ralph Kimball, "The Data Warehouse Toolkit – Practical Techniques for Building Dimensional Data Warehouse," John Wiley & Sons, Inc.
3. Matteo Golfarelli, Stefano Rizzi, "Data Warehouse Design - Modern Principles and Methodologies", McGraw Hill Publisher

Data Visualization			
Credit Hours:	3(2,1)	**Prerequisites:**	Data Warehousing & Business Intelligence

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Provides knowledge about importance, necessity, and justification of performing exploratory data analysis and visualization	C	2
Introduce various type of charts along with their alternatives solution to show same data from versatile aspects.	C	2
Improving the competency of the students to analyze different problems and select the most appropriate solution.	C	3
Use of R, various recent tools, and technologies to develop hands-on skills for exploratory data analysis and visualization.	C	3

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Introduction of Exploratory Data Analysis and Visualization, Building Blocks and Basic Operations; Types of Exploratory Graphs, single and multi-dimensional summaries, five number summary, box plots, histogram, bar plot and others; Distributions, their representation using histograms, outliers, variance; Probability Mass Functions and their visualization; Cumulative distribution functions, percentile-based statistics, random numbers; Modelling distributions, exponential, normal, lognormal, pareto; Probability density functions, kernel density estimation; Relationship between variables, scatter plots, correlation, covariance; Estimation and Hypothesis Testing; Clustering using K-means and Hierarchical; Time series and survival analysis; Implementing concepts with R (or similar language)

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. "Exploratory Data Analysis with R" by Roger D. Peng

Artificial Intelligence			
Credit Hours:	4(3,1)	**Prerequisites:**	Introduction to Data Science

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Understand the fundamental constructs of Lisp programming language.	C	2
Understand key concepts in the field of artificial intelligence	C	2
Implement artificial intelligence techniques and case studies	C	3

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

An Introduction to Artificial Intelligence and its applications towards Knowledge Based Systems; Introduction to Reasoning and Knowledge Representation, Problem Solving by Searching (Informed searching, Uninformed searching, Heuristics, Local searching, Min-max algorithm, Alpha beta pruning, Game-playing); Case Studies: General Problem Solver, Eliza, Student, Macsyma; Learning from examples; Natural Language Processing; Recent trends in AI and applications of AI algorithms. Lisp & Prolog programming languages will be used to explore and illustrate various issues and techniques in Artificial Intelligence.

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. Russell, S. and Norvig, P. "Artificial Intelligence. A Modern Approach", 3rd ed, Prentice Hall, Inc., 2015.
2. Norvig, P., "Paradigms of Artificial Intelligence Programming: Case studies in Common Lisp", Morgan Kaufman Publishers, Inc., 1992.
3. Luger, G.F. and Stubblefield, W.A., "AI algorithms, data structures, and idioms in Prolog, Lisp, and Java", Pearson Addison-Wesley. 2009.

English Composition and Comprehension			
Credit Hours:	3(3,0)	**Prerequisites:**	None

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Understand basic concepts of language learning and usage	C	2
Apply basic structures of English language	C	3
Tailor messages according to context, audience, and register	C	3

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Principles of writing good English, understanding the composition process: writing clearly; word, sentence and paragraph. Comprehension and expression; Use of grammar and punctuation; Process of writing, observing, audience analysis, collecting, composing, drafting and revising, persuasive writing, reading skills, listening skills and comprehension, skills for taking notes in class, skills for exams.

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. John E. Warriner. Warriner's English Grammar and Composition.
2. William Strunk Jr, The Elements of Style Workbook: Writing Strategies with Grammar Book, Classical Edition, 2017

Communication & Presentation Skills

Credit Hours:	3(3,0)	Prerequisites:	English Composition & Comprehension

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Develop an in depth understanding of Communication skills and to use these skills in formal and informal contexts	C	2
Develop the skill of active listening and responding to audience	C	2
Deliver effective speeches and presentations	C	3

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

This course will enable the students to organize messages that are appropriate to the audience and situation. Students improve oral communication skills for professional and social interaction through extensive pronunciation and conversational practice. Individual pronunciation assessments help students refine their language skills. Practice includes forming and communicating opinions on contemporary issues, developing formal and informal oral presentations and reports, giving and following directions. Through readings and written exercises, students learn how to form, communicate, and support their opinions and ideas in academic and professional settings. Students strengthen their reading skills and expand their vocabularies by reading and discussing a variety of adapted and authentic texts. They also may present findings in research reports.

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. Effective Tech Communication by Rizvi, 2005, Published by Tata McGraw Hill Companies.
2. The handbook of Communication skills, Third Edition, Edited by Owen Hargie, 2006
3. Communication Skills for Business Professionals 7 by Phillip Cenere, Robert Gill, Celeste Lawson, Michael Lewis, 2015, Published by Cambridge University Press

Technical & Business Writing			
Credit Hours:	3(3,0)	**Prerequisites:**	Communication & Presentation Skills

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Understanding the importance and applications of technical writing	C	1
Examine the content and style in technical writing by analyzing different user manuals, instruction leaflets and product descriptions.	C	4
Write professional letters, Memorandums, Emails, Text Messages, Business Proposals, Reports, etc.	C	3
Present the technical reports and other topics formally	C	2

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

The course introduces fundamentals of Technical Communication (Theories of Communication, ABC & Objectives of Technical Communication, 7 Cs of Effective Communication), writing process (stage 1, stage 2, stage 3), presentation skills, overview of technical documents (writing memoranda & e-mails, overview of formal letters), basics of writing reports (defining reports, determining the purpose & factors, gathering the information needed, interpreting the findings, writing short informal reports, writing long reports, understanding plagiarism, referencing sources), designing the final project and presentation.

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. Technical Communication by Mike Markel, 11th Edition, Published by Bedford/St. Martin's, 2014.
2. Writing for Science and Engineering: Papers, Presentations and Reports Elsevier insights by Heather Silyn-Roberts, 2nd Edition, PublishedbyNewnes, 2012.
3. The Craft of Scientific Presentations: Critical Steps to Succeed and Critical Errors to Avoid by Michael Alley 2nd Edition, Published by Springer Science & Business Media, 2013.
4. Rhetorical Grammar: Grammatical Choices, Rhetorical Effects By Martha J. Kolln, Loretta S. Gray, 7th Edition, Published byPearson Education, 2015.

Islamic Studies/Ethics

Credit Hours:	2(2,0)	Prerequisites:	None

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Students will be able to understand the meanings of	C	1
Quranic Verses & Hadiths	C	1
Students will have a strong relation with Islam	C	1
Students will be aware of basic teachings of Islam		

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Basic Themes of Quran, Introduction to Sciences of Hadith, Introduction to Islamic Jurisprudence, Primary & Secondary Sources of Islamic Law, Makken & Madnian life of the Prophet, Islamic Economic System, Political theories, Social System of Islam

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. Introduction to Islam by Dr Hamidullah, Papular Library Publishers Lahore
2. Principles of Islamic Jurisprudence by Ahmad Hassan, Islamic Research Institute, IIUI
3. Muslim Jurisprudence and the Quranic Law of Crimes, By Mir Waliullah, Islamic Books Services

Pakistan Studies			
Credit Hours:	2(2,0)	**Prerequisites:**	None

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Create awareness among students about Pakistan as an enlightened nation by comparing it with the rationale and endeavors for Pakistan's creation	C	2
Educate students about the key concepts in disciplines comprising Pakistan Studies, including history, economics, and political science	C	2

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

The course will cover culture, society and religion of Pakistan, political and constitutional development (shaping of the state structure; objective resolution; Constitutions of 1956, 1962 and 1973; democracy and authoritarianism), cultural issues, socio–economic and environmental issues in Pakistan (unemployment; double standard of education; poverty; gender issues; population growth; human right issues; pollution issues.), foreign policy of Pakistan, Pakistan in the community of the nations.

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. A Comprehensive Book of Pakistan Studies by M. Ikram Rabbani, 3rd Edition, Published by Caravan Book House, 2005

Professional Practices			
Credit Hours:	3(3,0)	**Prerequisites:**	None

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Introduce the basic concepts and importance of ethics that can be mapped in the computing professional's lives.	C	1
Highlight the Impact of social media and social implications of computing and networked communication regarding ethics and morality	C	1
An **understanding** of professional ethical theories and code of ethics (IEEE/ACM)	C	2

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Computing Profession, Computing Ethics, Philosophy of Ethics. The Structure of Organizations, Finance and Accounting, Anatomy of a Software House, Computer Contracts, Intellectual Property Rights, The Framework of Employee Relations Law and Changing Management Practices, Human Resource Management and IT, Health and Safety at Work, Software Liability, Liability and Practice, Computer Misuse and the

Criminal Law, Regulation and Control of Personal Information. Overview of the British Computer Society Code of Conduct, IEEE Code of Ethics, ACM Code of Ethics and Professional Conduct, ACM/IEEE Software Engineering Code of Ethics and Professional Practice. Accountability and Auditing, Social Application of Ethics.

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. Professional Issues in Software Engineering by Frank Bott, Allison Coleman, Jack Eaton and Diane Rowland, CRC Press; 3rd Edition (2000). ISBN-10: 0748409513
2. Computer Ethics by Deborah G. Johnson, Pearson; 4th Edition (January 3, 2009). ISBN-10: 0131112414
3. A Gift of Fire: Social, Legal, and Ethical Issues for Computing and the Internet (3rd Edition) by Sara Baase, Prentice Hall; 3rd Edition (2008). ISBN-10: 0136008488
4. Applied Professional Ethics by Gregory R. Beabout, University Press of America (1993). ISBN-10: 0819193747.

Introduction to Information and Communication Technologies

Credit Hours:	3(2,1)	Prerequisites:	None

Course Learning Outcomes (CLOs):

At the end of the course the students will be able to:	Domain	BT Level*
Understand basics of computing technology	C	1
Do number systems conversions and arithmetic	C	2
Have knowledge of types of software	C	2
Have knowledge of computing related technologies	C	3

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Brief history of Computer, Four Stages of History, Computer Elements, Processor, Memory, Hardware, Software, Application Software its uses and Limitations, System Software its Importance and its Types, Types of Computer (Super, Mainframe, Mini and Micro Computer), Introduction to CBIS (Computer Based Information System), Methods of Input and Processing, Class2. Organizing Computer Facility, Centralized Computing Facility, Distributed Computing Facility, Decentralized Computing Facility, Input Devices. Keyboard and its Types, Terminal (Dump, Smart, Intelligent), Dedicated Data Entry, SDA (Source Data Automation), Pointing Devices, Voice Input, Output Devices. Soft- Hard Copies, Monitors and its Types, Printers and its Types, Plotters, Computer Virus and its Forms, Storage Units, Primary and Secondary Memories, RAM and its Types, Cache, Hard Disks, Working of Hard Disk, Diskettes, RAID, Optical Disk Storages (DVD, CD ROM), Magnetic Types, Backup System, Data Communications, Data Communication Model, Data Transmission, Digital and Analog Transmission, Modems, Asynchronous and Synchronous Transmission, Simplex. Half Duplex, Full Duplex Transmission, Communications, Medias (Cables, Wireless), Protocols, Network Topologies (Star, Bus, Ring), LAN, LAN, Internet, A Brief History, Birthplace of ARPA Net, Web Link, Browser, Internet Services provider and Online Services Providers, Function and Features of Browser, Search Engines, Some Common Services available on Internet.

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. Introduction to Computer Information System by Geoffrey Steinberg, KamaljeetSanghera,Published byKendall Hunt Publishing Company, 2010.
2. Fundamentals of Computing by Kamaljeet Sanghera, Richard F. Taflinger, 3rd Edition, Published by Kendall Hunt Publishing Company, 2011.
3. Web and Network Data Science: Modeling Techniques in Predictive Analytics by Thomas W. Miller published by FT Press, 2014.
4. Semantics Empowered Web 3.0: Managing Enterprise, Social, Sensor, and Cloud-based Data and Services for Advanced Applications (Synthesis Lectures on Data Management) by Amit Sheth and Krishnaprasad Thirunarayan Published by Morgan & Claypool, 2013.

Introduction to Data Science

Credit Hours:	3(2,1)	Prerequisites:	Object Oriented Programming

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Describe what Data Science is and the skill sets needed to be a data scientist.	C	2
Apply EDA and the Data Science process in a case study	C	3
Comprehend the fundamental constructs of Python programming language.	C	2
Apply basic machine learning algorithms to solve real world problems of moderate complexity.	C	3

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Introduction: What is Data Science? Big Data and Data Science hype, Datafication, Current landscape of perspectives, Skill sets needed; Statistical Inference: Populations and samples, Statistical modeling, probability distributions, fitting a model, Intro to Python; Exploratory Data Analysis and the Data Science Process; Basic Machine Learning Algorithms: Linear Regression, k-Nearest Neighbors (k-NN), k-means, Naive Bayes; Feature Generation and Feature Selection; Dimensionality Reduction: Singular Value Decomposition, Principal Component Analysis; Mining Social-Network Graphs: Social networks as graphs, Clustering of graphs, Direct discovery of communities in graphs, Partitioning of graphs, Neighborhood properties in graphs; Data Visualization: Basic principles, ideas and tools for data visualization; Data Science and Ethical Issues: Discussions on privacy, security, ethics, Next-generation data scientists

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. Foundations of data science, Blum, A., Hopcroft, J., & Kannan, R., Vorabversion eines Lehrbuchs, 2016.
2. An Introduction to Data Science, Jeffrey S. Saltz, Jeffrey M. Stanton, SAGE Publications, 2017.
3. Python for everybody: Exploring data using Python 3, Severance, C.R., CreateSpace Independent Pub Platform. 2016.
4. Doing Data Science, Straight Talk from the Frontline, Cathy O'Neil and Rachel Schutt,O'Reilly. 2014.
5. Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data, EMC Education Services, John Wiley & Sons, 2015.

Artificial Neural Networks

Credit Hours:	3(3,0)	Prerequisites:	Artificial Intelligence

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Understand the fundamentals of neural networks in AI	C	2
Explain how simple ANNs can be designed	C	2
Apply ANN for classification Problems	C	3
Differentiate between different Networks and their learning laws	C	4

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Introduction and history of neural networks, Basic architecture of neural networks, Perceptron and Adaline (Minimum Error Learning) for classification, Gradient descent (Delta) rule, Hebbian, Neo-Hebbian and Differential Hebbian Learning, Drive Reinforcement Theory, Kohonen Self Organizing Maps, Associative memory, Bi-directional associative memory (BAM), Energy surfaces, The Boltzmann machines, Backpropagation Networks, Feedforward Networks; Introduction to Deep learning and its architecture.

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. Neural Network Design, 2nd Edition, Martin T. Hagan, Howard, B. Demuth, Mark Hudson Beale and Orlando De Jesus, Publisher: Martin Hagan; 2 edition (September 1, 2014), ISBN-10: 0971732116
2. An Introduction to Neural Networks, James A Anderson, Publisher: A Bradford Book (March 16, 1995), ISBN-10: 0262011441
3. Fundamentals of Artificial Neural Networks, Mohammad Hassoun, Publisher: A Bradford Book (January 1, 2003), ISBN-10: 0262514672

Data Mining			
Credit Hours:	3(2,1)	**Prerequisites:**	Artificial Intelligence

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Apply preprocessing techniques on any given raw data.	C	3
Select and **apply** proper data mining algorithm to discover interesting patterns	C	3
Analyze and extract patterns to solve problems and point out how to deploy solution	C	4
Evaluate systematically supervised, semi supervised and unsupervised models and algorithms with respect to their accuracy	C	4

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Introduction to data mining and basic concepts, Pre-Processing Techniques & Summary Statistics, Association Rule mining using Apriori Algorithm and Frequent Pattern Trees, Introduction to Classification Types, Supervised Classification (Decision trees, Naïve Bayes Classification, K-Nearest Neighbors, Support Vector Machines etc.), Unsupervised Classification (K Means, K Median, Hieratical and Divisive Clustering, Kohonan Self Organizing maps), outlier & anomaly detection, Web and Social Network Mining, Data Mining Trends and Research Frontiers. Implementing concepts using Python

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. Jiawei Han & Micheline Kamber, Jian Pei (2011). Data Mining: Concepts and Techniques, 3rd Edition.
2. Pang-Ning Tan, Michael Steinbach, and Vipin Kumar (2005). Introduction to Data Mining.
3. Charu C. Aggarwal (2015). Data Mining: The Textbook D. Hand, H. Mannila, P. Smyth (2001). Principles of Data Mining. MIT Press.

Digital Image Processing			
Credit Hours:	3(3,0)	**Prerequisites:**	None

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Understand the basics, applications in general, working inside the digital camera, sampling and quantization, image representation, etc.	C	1
Implement image enhancement, image segmentation, image transformations, spatial and frequency domain processing	C	3
Evaluate the performance of different image processing	C	4

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

The human visual system, electromagnetic system, working and components inside digital camera, pixels, image representation, sampling, quantization, mathematics of image formation, convolution, camera projection, point-based image processing, Fourier theory, image filtering in spatial and frequency domain, wavelets, image registration, morphological operations, color models, multispectral images, feature detection, image segmentation, Pattern recognition, etc.

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. Digital Image Processing, Rafael C. Gonzalez & Richard E Woods, Pearson, 2007, ISBN-13: 978-0131687288.
2. Fundamentals of Digital Image Processing, Anil K. Jain, Pearson Edun, 2001.
3. Digital Image Processing and Analysis, B. Chanda and D. Dutta Majumdar, PHI, 2003.

Deep Learning			
Credit Hours:	3(3,0)	**Prerequisites:**	Artificial Neural Networks

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Apply deep learning algorithms to real-world problems	C	3
Analyze results from deep learning to select appropriate solutions	C	4
Code the novel neural network architectures from scratch and evaluating the performance on application specific standard benchmarks	C	3

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Basics of deep learning, learning networks, Shallow vs. Deep learning etc.; Machine learning theory – training and test sets, evaluation, etc. Theory of Generalization; Multi-layer perceptrons, error back-propagation; Deep convolutional networks, Computational complexity of feed forward and deep convolutional neural networks; Unsupervised deep learning including auto-encoders; Deep belief networks; Restricted Boltzman Machines; Deep Recurrent Neural Networks (BPTT, LSTM, etc.); GPU programming for deep learning CuDNN; Generative adversarial networks (GANs); Sparse coding and auto-encoders; Data augmentation, elastic distortions, data normalization; Mitigating overfitting with dropout, batch normalization, dropconnect; Novel architectures, ResNet, GoogleNet, etc

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. Deep Learning by Ian Goodfellow, Yoshua Bengio, Aaron Courville (http://www.deeplearningbook.org/)
2. Deep learning with python by Francoise Chollet, ISBN-10: 9781617294433, 2017

Theory of Automata & Formal Languages

Credit Hours:	3(3,0)	Prerequisites:	None

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Explain and manipulate the different concepts in automata theory and formal languages such as formal proofs, automata, regular expressions, Turing machines etc.	C	2
Prove properties of languages, grammars and automata with rigorously formal mathematical methods	C	2
Design of automata, RE and CFG	C	3
Transform between equivalent NFAs, DFAs and Res	C	3
Define Turing machines performing simple tasks	C	2
Differentiate and manipulate formal descriptions of languages, automata and grammars with focus on regular and context-free languages, finite automata and regular expressions.	C	3

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Finite State Models: Language definitions preliminaries, Regular expressions/Regular languages, Finite automata (FAs), Transition graphs (TGs), NFAs, Kleene's theorem, Transducers (automata with output), Pumping lemma and non-regular language Grammars and PDA: CFGs, Derivations, derivation trees and ambiguity, Simplifying CFLs, Normal form grammars and parsing, Decidability, Context sensitive languages, grammars and linear bounded automata (LBA), Chomsky's hierarchy of grammars Turing Machines Theory: Turing machines, Post machine, Variations on TM, TM encoding, Universal Turing Machine, Defining Computers by TMs.

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. Introduction to computer theory, Daniel I. A. Cohen, 2nd Edition
2. Automata, Computability and Complexity: Theory and Applications, by Elaine Rich, 2011
3. An Introduction to Formal Languages and Automata, by Peter Linz, 4th edition, Jones & Bartlett Publishers, 2006
4. Theory of Automata, Formal Languages and Computation, by S. P. Eugene, Kavier, 2005, New Age Publishers

Privacy Preservation

Credit Hours:	3(3,0)	Prerequisites:	None

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Decide, given an application, if it should be formulated as a data privacy problem.	C	2
Understanding of how (and why) randomness (or uncertainty) provides privacy protection.	C	2
Analyze real-world privacy problems, identify which privacy-preserving methods are appropriate, and implement the private algorithms in code.	C	4
To evaluate and compare privacy-preserving algorithms.	C	3

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Why Data Privacy? Privacy definitions (k-anonymity, ℓ-diversity) Review: probability and tutorial on Numpy, Foundation of Differential Privacy, Local Privacy Models, Convex Optimization, Relaxations of Differential Privacy, Foundation of deep learning, Spring Break - No Classes, Neural Networks for Supervised Learning, Neural Networks for Generative Models

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. The Algorithmic Foundations of Differential Privacy Author: Cynthia Dwork and Aaron Roth Publisher: Now Publisher ISBN: 978-1-60198-818-8
2. Differential Privacy: A Primer for a Non-technical Audience Author: Nissim et al. Harvard University Privacy Tools Project

Graph Theory

Credit Hours:	3(3,0)	Prerequisites:	

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
To introduce the fundamental concepts of Graph Theory. To provide knowledge for application of Graph Theory in subsequent courses in the design and analysis of algorithms, computability theory, software engineering, and computer systems.	C C	1 2

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Introduction to Graph Theory, Basic definitions, computer representations and properties of Graph, Data structure for representing Graphs, Fundamental theorem of Graph Theory, Isomorphic and Special Graphs, Properties of Trees and Forests, Binary tree, Balanced binary tree, Directed and Undirected rooted tree, Minimum Spanning Tree algorithms and implementation, Path and Distance in graphs, Shortest path algorithms and implementation, Cycle and distance in weighted graph and digraphs, Distance algorithms and implementation, Eulerian graphs and Hamiltonians graphs with applications, Flow networks, Max-flow Min-cut Theorem, Graph coloring, Edge coloring, Planar graphs, Four color theorem, Deadlock of computer system, Matching Algorithms, Dominance & Ramsey theory.

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. Graph Theory & Applications (1st Edition) by Fournier. Published by Wiley-ISTE, 2011.
2. Applied Algorithmic Graph Theory (1st Edition) by Chartrand. Published by McGrawHill College, 1995.
3. Handbook of Graph Theory (Series Edition) by Jonathan Published by CRC Press, 2004.
4. Graph Theory with Applications (8th Edition) by J. A. Bondy, Published Elsevier USA, 1982

Cloud Computing

Credit Hours:	3(3,0)	Prerequisites:	None

Course Learning Outcomes (CLOs):		
At the end of the course the students will be able to:	**Domain**	**BT Level***
Describe and understand cloud computing concepts, services, applications and platforms.	C	1
Understand and identify cloud computing tools and techniques for analyzing data and adopting Cloud Computing services and tools in real life scenarios.	C	1
Analyze, contrast, and evaluate the key trade-offs between multiple approaches to cloud system design, and identify appropriate design choices when solving real-world cloud computing problems.	C	3

* BT= Bloom's Taxonomy, C=Cognitive domain, P=Psychomotor domain, A= Affective domain

Course Content:

Introduction to the course: defining the Cloud Computing, the roots/brief history of Cloud Computing, Characteristics of Cloud Computing/ advantages and disadvantages of adopting Cloud Computing. Cloud concepts and capabilities across the various Cloud service models including Infrastructure as a Service (IaaS), Platform as a Service (PaaS), Software as a Service (SaaS). Cluster, Grid and Clod, Mainstream Cloud infrastructure services and related vendor solutions PaaS Cloud vendor platforms including AWS, Google App Engine, Microsoft Azure, Eucalyptus, OpenStack Cloud resources allocation, management and monitoring capabilities. Cloud resource scheduling, resource utilization and energy efficiency, Scheduling algorithms for the cloud. Virtual machines and hypervisors, virtualization, OS support for virtualization, VM software and platforms, Virtual machines and containers, Case Study: Amazon EC2. Cloud security model and associated challenges, Security risks, Privacy and trust on the Cloud, Security of cloud infrastructure, Cloud deployment models, Cloud Storage, Cloud networking. Obstacles to cloud computing, Issues and challenges, Possible solutions. Cloud computing and other platforms, P2P Computing, Distributed systems. Open Source and Commercial Clouds, Server Consolidation and Scalability in cloud.

Teaching Methodology:

Lectures, Written Assignments, Semester Project.

Course Assessment:

Sessional Exam, Home Assignments, Quizzes, Project, Final Exam

Reference Materials:

1. Cloud computing for beginning to end, Ray J, Rafaels April 2015
2. L. Wang, R. Ranjan, J. Chen, and B. Benatallah, Cloud Computing: Methodology, Systems, and Applications, CRC Press, Boca Raton, FL,USA, ISBN: 9781439856413, October 2011.
3. Buyya R., Broberg J., Goscinski A., Cloud Computing: Principles and Paradigms, John Wiley & Sons Inc., ISBN: 978-0-470-88799-8, 2011.