Department of Information Technology, NITK Surathkal

Bachelor of Technology in Artificial Intelligence

Basic Science Core (BSC)			**Programme Specific Electives (PSE)** *[Two courses must be taken from each cluster]*		
MA110	Engineering Mathematics – I	(3-0-0) 3	**Cluster 1: Computing Core**		
PH110	Physics	(3-1-0) 4	IT213	Database Systems	(3-0-2) 4
PH111	Physics Lab	(0-0-2) 1	IT355	Autonomous Agents	(3-0-2) 4
MA111	Engineering Mathematics – II	(3-0-0) 3	IT371	Operating Systems	(3-0-2) 4
CY110	Chemistry	(3-0-0) 3	IT431	Distributed Computing	(3-0-2) 4
CY111	Chemistry Lab	(0-0-3) 2	IT436	Cloud Computing	(3-0-2) 4
Engineering Science Core (ESC)			IT437	Quantum Computing	(3-0-2) 4
EC100	Elements of Electronics & Communication Engineering	(2-0-0) 2	IT472	Computer Networks	(3-0-0) 3
			IT473	Cognitive Networks	(3-0-2) 4
ME111	Engineering Graphics	(1-0-3) 3	IT474	Formal Languages & Automata Theory	(3-0-0) 3
AM110	Engineering Mechanics	(3-0-0) 3	IT475	Computer Organisation & Architecture	(3-0-0) 3
CS110	C Programming	(3-0-0) 3	IT477	Digital System Design	(3-0-2) 4
CS111	C Programming Lab	(0-0-3) 2	IT479	Signals and Systems	(3-0-2) 4
Humanities and Social Science Core (HSC)			**Cluster 2: Human Machine Interaction**		
SM110	Professional Communication	(3-0-0) 3	IT308	Brain Computer Interfaces	(3-0-2) 4
SM300	Engineering Economics	(3-0-0) 3	IT356	Natural Language Processing	(3-0-2) 4
SM302	Principles of Management	(3-0-0) 3	IT357	Computer Vision	(3-0-2) 4
Programme Core (PC)			IT424	Computational Auditory Perception	(3-0-2) 4
IT111	Fundamentals of Computer Systems	(4-0-0) 4	IT425	Computational Visual Perception	(3-0-2) 4
IT112	Computer Systems Lab	(0-0-2) 1	IT432	Computational Photography	(3-0-2) 4
IT151	Python Programming	(3-0-0) 3	IT439	Sentiment Analysis	(3-0-0) 3
IT152	Python Programming Lab	(0-0-2) 1	IT445	User Experience Design	(3-0-2) 4
IT207	Human Intelligence	(3-0-0) 3	IT476	Human Centered Computing	(3-0-2) 4
IT208	Discrete Mathematics	(3-0-2) 4	**Cluster 3: Artificial Intelligence / Machine Learning**		
IT209	Data Structures and Algorithms	(3-0-2) 4	IT260	Robotics Programming	(3-0-2) 4
IT211	Probability and Statistics	(3-0-2) 4	IT358	Soft Computing	(3-0-2) 4
IT255	Artificial Intelligence	(3-0-2) 4	IT359	Pattern Recognition	(3-0-2) 4
IT256	Applied Linear Algebra	(3-0-2) 4	IT427	Genetic Algorithms	(3-0-2) 4
IT257	Design and Analysis of Algorithms	(3-0-2) 4	IT435	Computational Biology	(3-0-2) 4
IT258	Data Science	(3-0-2) 4	IT443	Stochastic Processes	(3-0-2) 4
IT304	Optimization Techniques	(3-0-2) 4	IT469	AI in Healthcare	(3-0-2) 4
IT305	Game Theory	(3-0-2) 4	**Cluster 4: Data Science and Applications**		
IT306	Parallel and Distributed Problem Solving	(3-0-2) 4	IT212	Intelligent Data Management	(3-0-2) 4
IT307	Machine Learning	(3-0-2) 4	IT259	Data Visualization	(3-0-2) 4
IT353	Deep Learning	(3-0-2) 4	IT367	Information Retrieval	(3-0-2) 4
IT354	Reinforcement Learning	(3-0-2) 4	IT369	Performance Modeling	(3-0-2) 4
Major Project (MP)			IT370	Time Series Analysis	(3-0-2) 4
IT448	Major Project-I	(0-0-3) 2	IT438	Big Data Analytics	(3-0-2) 4
IT498	Major Project-II	(0-0-6) 4	IT480	Social Computing	(3-0-2) 4
Mandatory Learning Courses (MLC)			IT478	Data Mining	(3-0-2) 4
CV110	Environmental Studies	(1-0-0) 1	IT481	Capstone Project	4
SM111	Professional Ethics and Human Values	(1-0-0) 1	**Cluster 5: Cyber-physical Systems**		
ME100	Introduction to Design Thinking	(2-0-0) 2	IT368	Internet of Things	(3-0-2) 4
SA401	Liberal arts courses/cocurricular / extracurricular activities	10	IT426	Smart Systems Development	(3-0-2) 4
			IT428	Industry 4.0	(3-0-2) 4
IT447	Practical Training	1	IT429	Number Theory and Cryptography	(3-0-2) 4
IT289	Seminar	1	IT430	Quantum Cryptography	(3-0-2) 4
B.Tech (Minor) in AI (for other branches)			IT433	Blockchain Technology	(3-0-2) 4
IT209	Data Structures and Algorithms	(3-0-2) 4	IT434	Digital Forensics	(3-0-2) 4
IT255	Artificial Intelligence	(3-0-2) 4	IT442	Autonomous Cyber Physical Systems	(3-0-0) 3
IT258	Data Science	(3-0-2) 4	IT471	Cyber Security	(3-0-2) 4
IT306	Parallel and Distributed Problem Solving	(3-0-2) 4			
IT307	Machine Learning	(3-0-2) 4			

Suggested Plan of Study

Semester	I	II	III	IV	V	VI	VII	VIII
1	MA110	MA111	IT207	IT255	IT304	IT353	IT447	IT498
2	CY110	PH110	IT208	IT256	IT305	IT354	IT448	**Elective-9**
3	CY111	PH111	IT209	IT257	IT306	SM302	SA401	**Elective-10**
4	AM110	EC100	IT211	IT258	IT307	**Elective-4**	**Elective-6**	
5	CS110	ME111	**Elective-1**	IT289	SM300	**Elective-5**	**Elective-7**	---
6	CS111	SM110	---	**Elective-2**	**Elective-3**	---	**Elective-8**	---
7	CV110	SM111	---	---	---	---	---	---
8	ME100	IT151	---	---	---	---	---	---
9	IT111	IT152	---	---	---	---	---	---
10	IT112	---	---	---	---	---	---	---

Degree Requirements

Category of Courses	**Minimum Credits to be Earned**
Basic Science Core (BSC)	16
Engineering Science Core (ESC)	13
Humanities and Social Sciences Core (HSC)	09
Programme Core (PC)	64
* Programme Specific Electives (PSE)	37
Major Project (MP)	06
Mandatory Learning Courses (MLC)	16
Total	**161**

*At least 7 electives with (3-0-2) 4 credit courses should be selected.

PROGRAM CORE

IT111 Fundamentals of Computer Systems (4-0-0) 4

Introduction to computer systems, Program structure and execution: representing and manipulating Information, Machine level representation of Programs, Processor Architecture, Optimizing program performance, The memory hierarchy, Linking, Exceptional Control flow, Virtual Memory, Fundamentals of Operating Systems.

Randal E. Bryant, David R. O'Hallaron, Computer Systems: A Programmer's Perspective, Pearson, 2016
Carl HAmacher, Zvonko Vranesic, SAfeat Zaky, Computer Organization, McGraw Hill, 2011
Abraham Silberschatz, PEter B Galvin, Gerrg Gagne, Operating Systems, Wiley, 2015

IT112 Computer Systems Lab (0-0-2) 1

Basic Linux Commands, Shell programming, Learn to write, test, and debug simple C programs, Learn C programs with conditionals and loops, Pointers, Memory allocation and Memory management using C, Basic System Calls, Introduction to profiling.

IT151 Python Programming (3-0-0) 3

Introduction to Programming Languages, Python Basics, Variables and Data Types, Control Structures, Repetition structures, Functions and Modules, Strings, Lists, File Input and Output, Basic Data Structures, Object-Oriented Programming. Python web frameworks

Martin C. Brown, Python: The Complete Reference, McGraw Hill Education; Fourth edition, 2018
Mark Summerfield, Programming in Python 3: A Complete Introduction to the Python Language, Pearson, 2018

IT152 Python Programming Lab (0-0-2) 1

Learn to write, test, and debug simple Python programs, Loops and Conditionals, Use OOP concepts in Python programs, Read and write data from/to files in Python. String Operations, Basic Data structures and Algorithms. Python web frameworks

IT207 Human Intelligence (3-0-0) 3

Introduction: The Mechanics of Intelligence, Human Intelligence and the Brain; Approaches of Human Intelligence: Biological, Cognitive, Cultural and Psychometric Approaches; Applications of Human Intelligence Research: Extremes of Intelligence, Group and Sex Differences, Environment Effects on Intelligence, Demography of Intelligence.

Robert J. Sternberg, "Human Intelligence - An Introduction", Cambridge University Press, 2020
N. J. Mackintosh, "IQ and Human Intelligence";, Oxford University Press, 2nd Edition, 2011.
Earl0Hunt, "Human Intelligence" Cambridge University Press, 2011.

IT208 Discrete Mathematics (3-0-2) 4

Fundamentals of Discrete Mathematics: Counting, Logic, Set Theory, Proof Techniques, Relations and Functions: Generating functions, Recursive relations; Introduction to Graph Theory: Vertex degrees, paths, Planar graphs, Trees; Basic Algebra: Groups, Monoids, Rings, Lattice Theory, Applications of DM in AI Systems.

R.P. Grimaldi, B.V. Ramana, Discrete and Combinatorial Mathematics: An Applied Introduction, 5th Edition, Pearson, 2008.
B. Kolman, R.C. Busby, S.C. Ross, Discrete Mathematical Structures, Pearson Education India; 6 edition , 2015.
Kenneth Rossen, Discrete Mathematics and its Application, 7th Edition, McGraw-Hill, 2011.
L. Lovasz, Combinatorial Problems and Exercises, 2nd Edition, North Holland, 1993.

IT209 Data Structures and Algorithms (3-0-2) 4

Elementary Data Types and Abstract data types. Computational model and complexity of algorithms (running time and space metrics), Introduction to Asymptotic notation; Worst- case, Best -case, Average-case and amortized analysis. Arrays, Linear search and Binary search on sorted arrays. List ADT and its implementation using arrays and linked lists. Types of linked lists: Single, Double, circular linked lists and their applications. Stack ADT and Queue ADT implementations with applications. Dynamic set ADT and Dictionary ADT. Hash tables – collisions, open and closed hashing, choosing good hash functions. Trees: Definitions and Representations; Tree traversals and their applications. Binary Search Trees. AVL trees, Red-black trees, B-trees; Priority Queue ADT and its implementations using Binary heaps. Applications of Priority Queues. Sorting algorithms: Merge sort and Quicksort. Randomized Quick sort and its analysis. Linear-time sorting algorithms like Radix and Counting sort. Graphs: Definitions and representations. Depth first and breadth-first search and their applications. Basic Graph algorithms like Dijkstra's shortest path algorithm and Kruskal's MST algorithm.

T H Cormen, C E Leiserson, R L Rivest and C Stein, Introduction to Algorithms, 3rd Edition, PHI Learning, 2010.
S. Horowitz. Fundamentals of Data Structures in C, Universities Press, 2nd Edition, 2008.
Michael T. Goodrich and Roberto Tamassia. Algorithm Design, Wiley, 1st Edition, 2006.
Knuth D.E., The Art of Computer Programming, Vol. I: Fundamental Algorithms, Addison Wesley, 3rd Ed., 1997.

IT211 Probability and Statistics (3-0-2) 4

Probability rules; independence; system reliability (parallel, series); Conditional Probability, Law of Total Probability, Bayes Rule; Definition of Random Variable, Discrete Random Variables Bernoulli, Binomial; probability mass function; Binomial, Hyper geometric, Geometric, Negative Binomial, Poisson and Poisson approximation of Binomial; Expectation and Variance of a Discrete Random Variable; Continuous Distributions (density), including joint distributions and joint density mean and variance of a density; Gaussian density; Exponential and Gamma densities, Central Limit Theorem; Simulation of Random Variables, Statistics and sampling distribution of the sample mean; Statistics and sampling distribution of the sample proportion; Statistical inference; Parameter Estimation (Method of Moments, Maximum Likelihood Method); Confidence Intervals (Pivotal Quantity Method) Hypothesis Testing; type I and type II errors; **Applications and use cases of AI**.

DeGroot & Schervish, Probability and Statistics (4th Edition) Pearson (2011).

Wasserman, All of Statistics: A Concise Course in Statistical Inference Springer (2004).

IT255 Artificial Intelligence (3-0-2) 4

Introduction to AI-Problem formulation, Problem Definition -Production systems, Control strategies, Search strategies. Problem characteristics, Production system characteristics -Specialized production system- Problem solving methods – Problem graphs, Matching, Indexing and Heuristic functions -Hill Climbing-Depth first and Breath first, Constraints satisfaction – Measure of performance and analysis of search algorithms.- Game playing – Knowledge representation, Knowledge representation using Predicate logic, Introduction to predicate calculus, Resolution, Use of predicate calculus, Knowledge representation using other logic-Structured representation of knowledge- Basic plan generation systems – Strips -Advanced plan generation systems – K strips -Strategic explanations -Why, Why not and how explanations. Learning- Machine learning, adaptive Learning.-Expert systems – Architecture of expert systems, Roles of expert systems – Knowledge Acquisition – Meta knowledge, Heuristics. Typical expert systems – MYCIN, DART, XOON, Expert systems shells.

Kevin Night and Elaine Rich, Nair B., "Artificial Intelligence (SIE)", McGraw Hill- 2008.)

Dan W. Patterson, "Introduction to AI and ES", Pearson Education, 2007

Peter Jackson, "Introduction to Expert Systems", 3rd Edition, Pearson Education, 2007.

Stuart Russel and Peter Norvig "AI – A Modern Approach", 2nd Edition, Pearson Education 2007.

IT256 Applied Linear Algebra (3-0-2) 4

Vectors: definition, scalars, addition, scalar multiplication, inner product(dot product), vector projection, cosine similarity, orthogonal vectors, normal and orthonormal vectors, vector norm, vector space, linear combination, linear span, linear independence, basis vectors; Matrices: definition, addition, transpose, scalar multiplication, matrix multiplication, hadamard product, functions, linear transformation, determinant, identity matrix, invertible matrix and inverse, rank, trace, popular type of matrices- symmetric, diagonal, orthogonal, orthonormal, positive definite matrix; Least Squares: Least Square Problem and Solutions; EigenValues; Eigenvectors: Concept, Significance; Principal Component Analysis: Concept, Properties, Applications; Singular Value Decomposition: Concept, Properties, Applications.

W. Cheney, D. Kincaid, "Linear Algebra Theory and Applications";, Jones & Bartlett, Student Ed.. 2010

Gilbert Strang, "Linear Algebra and Its Applications", Cengage Learning, 4th Edition, 2007

Stephen Boyd, Lieven Vandenberghe, "An Introduction to Applied Linear Algebra: Vectors, Matrices, and Least Squares", Cambridge University Press, 2018.

IT257 Design and Analysis of Algorithms (3-0-2) 4

Models of computation, algorithm analysis and asymptotic notation, time and space complexity, average and worst case analysis, lower bounds. Amortized analysis. Algorithm design techniques: recursion, branch-and-bound, divide and conquer, greedy, dynamic programming, randomization. Applications of the above techniques to a variety of problems: Stable matching, linear- time selection, integer, polynomial and matrix multiplications, Fast Fourier Transforms (FFT): FFT Algorithms, computing shortest paths and minimum spanning trees, etc. Reductions and the theory of NP Completeness, Approximation algorithms.

Jon Kleinberg and Eva Tardos, Algorithm Design, 1st Edition, Pearson Education India, 2013.

S Dasgupta, C Papadimitriou, U Vazirani, Algorithms, McGraw-Hill Education, 2006.

T H Cormen, C E Leiserson, R L Rivest, C Stein, Introduction to Algorithms, 3rd Edition, PHI, 2010. Steven S Skiena, The Algorithm Design Manual, 2nd Edition, Springer-Verlag, 2nd Edition, 2013. Michael T. Goodrich and Roberto Tamassia. Algorithm Design, Wiley, 1st Edition, 2006.

Horowitz and Sahni, Fundamentals of Computer Algorithms, Galgotia Publications, 2nd Edition, 2009

IT258 Data Science (3-0-2) 4

Introduction to Data science fundamentals, Nature of Data and its characteristics, Total information awareness, Bonferroni's Principle, Rhine's paradox, Recap of Statistical and Inferential Analysis, Data preprocessing, Data wrangling, Data exploration, Dealing with missing data – single and multiple data imputation, Entropy based techniques, Monte Carlo and MCMC simulations; Correcting inconsistent data – Deduplication, Entity resolution, Pairwise Matching; Fellegi-Sunter Model, Advanced processing- Regression, Correlation, Covariance analysis, Aggregation, Sampling, Dimensionality Reduction; Feature extraction and feature selection; Graph data analysis,

Stream processing and online analytics, Dealing with infinite length, concept drift, concept/feature evolution, Visual analytics, Current trends and research.

Jure Leskovec, Anand Rajaraman and Jeffrey Ullman, "Mining of Massive Datasets" Cambridge University Press, 2014
Sinan Ozdemir, "Principles of Data Science - Second Edition" Packt Publishing, 2018
Sam Lau, Joey Gonzalez, and Deb Nolan, "Principles and Techniques of Data Science "
Jeffrey S. Saltz and Jeffrey M. Stanton, "An Introduction to Data Science", Sage Publications, 2017
Davy Cielen, Arno D.B. Meysman, Mohamed Ali Introducing Data Science: Big Data, Machine Learning, and More", 2016
Garrett Grolemund, Hadley Wickham, "R for Data Science"O'Reilly, 2017
Nina Zumel and John Mount, "Practical Data Science with R", 2014

IT304 Optimization Techniques (3-0-2) 4

Introduction to Optimization, Convex Sets, Convex Functions, Lagrange Duality, Convex Optimization Algorithms, Second-order cone models, Semidefinite programming, Semi-infinite programming, Minimax, Sublinear algorithms, Interior Point Methods, Active set, Stochastic gradient, Coordinate descent, Cutting planes method, Applications to Image/Video/Multimedia Processing

Suvrit Sra, Sebastian Nowozin and Stephen J. Wright Optimization for machine learning. MIT Press, 2012.
Roberto Battiti, Mauro Brunato. The LION Way: Machine Learning plus Intelligent Optimization. Createspace Independent Pub, 2014

IT305 Game Theory (3-0-2) 4

Introduction to Game Theory, Quantifying the Inefficiency of Equilibrium: Nash Equilibrium, Routing Games and Congestion Games, Network Formation and Games in Networks, Price of Anarchy and Price of Stability, The Smoothness Framework, Coalitional Stability, Auctions and Mechanism Design: Algorithmic Mechanism Design and Auctions, Second-price and First-price Auctions, Combinatorial Auctions, Truthful Mechanisms, Approximately Efficient Mechanisms, Bayesian Mechanism Design, Maximizing Revenue in Auctions, Ad Auctions, Sponsored-Search Auctions, Quality of Stable Solutions in Simple Auction Mechanisms; Markets and Pricing: Social Welfare and Walrasian Equilibrium, Gross-Substitutes, Single-Minded Valuations, Maximizing Revenue via Pricing, Sequential Buyer Arrival, Combinatorial Walrasian Equilibrium; Algorithmic Aspects of Equilibrium: Existence and Complexity of Finding Equilibrium, Correlated and Coarse-Correlated Equilibrium, No-regret Learning

Noam Nisan, Tim Roughgarden, Eva Tardos, Vijay V. Vazirani, Algorithmic Game Theory, Cambridge University Press,2007.
Ronald Cohn Jesse Russell, Algorithmic Game Theory, VSD Publishers, 2012.

IT306 Parallel and Distributed Problem Solving (3-0-2) 4

Introduction to Parallel Computer Architectures, Shared memory and distributed memory programming techniques, Parallel Programming with OpenMP, MPI, Parallel Programming techniques like Task Parallelism using TBB, TL2, Cilk++ etc. Introduction to accelerator and heterogeneous programming using CUDA/OpenCL, Xeon-phi and FLGAs. Optimization of DL training and inference on parallel architectures. Projects in TensorFlow/PyTorch to implement a few of the techniques introduced in this course.

J. Dongara, I. Foster, G. Fox, W. Cropp et al, "Sourcebook of Parallel Programming", Morgan Kaufmann, 2002.
Barbara Chapman et.al, "OpenMP: Portable Shared Memory Parallel Programming", Scientific & Engineering Computation, MIT 2008.
B. Wilkinson and M. Allen, "Parallel Programming: Techniques and Applications", 2nd ed., Pearson, 2004.
Benedict R. Gaster et al., Heterogeneous Computing with OpenCL, 2nd Edition, Morgan Kaufmann. 2012.
Rezaur Rahman, Intel Xeon-Phi Coprocessor Architecture/Tools - The Guide for App. Developers, Apress, 2013.
CUDA for Engineers by Duane Storti and Mete Yurgotlu, Addison-Wesley, 2016.

IT307 Machine Learning (3-0-2) 4

Introduction: Basic principles, Applications, Challenges. Supervised learning: Linear Regression with one variable and multiple variables, Gradient Descent, Classification, Logistic Regression, Overfitting, Regularization, Support Vector Machines, Artificial Neural Networks, Perceptrons, Multilayer networks, back-propagation, Decision Trees, Ensemble methods, Unsupervised learning: Clustering (K-means, K-mediods, Hierarchical), Dimensionality reduction: Principal Component Analysis, Applications of machine learning methods.

Ethem Alpaydin, ―Introduction to Machine Learning, Third Edition, MIT Press, 2014
Jason Bell,Machine learning Hands on for Developers and Technical Professionals‖, First Edition, Wiley, 2014
Peter Flach, ―Machine Learning: The Art and Science of Algorithms that Make Sense of Data, First Edition, Cambridge University Press, 2012.
Stephen Marsland, ―Machine Learning – An Algorithmic Perspective, Second Edition, Chapman and Hall/CRC Machine Learning and Pattern Recognition Series, 2014.
Tom M Mitchell, ―Machine Learning‖, First Edition, McGraw Hill Education, 2013.

IT353 Deep Learning (3-0-2) 4

Deep Networks: Deep FeedForward Networks, Regularization for Deep Learning, Optimization for Training Deep Models, Convolutional Neural Networks, Sequence Modeling - Recurrent and Recursive Nets Autoencoders- Transfer learning-. Practical Methodology, Applications of Deep Learning, Deep Generative Models, Research Trends

Josh Patterson and Adam Gibson, "Deep learning: A Practitioner's Approach", O'Reilly, 2017
Ian Goodfellow, Y. Bengio and A. Courville, "Deep Learning", MIT Press, 2016.
Michael A. Nielsen, "Neural Networks and Deep Learning", Determination Press, 2015
Li Deng and Dong Yu, "Deep Learning: Methods and Applications", 2013
Koller, D. and Friedman, N. Probabilistic Graphical Models . MIT Press. 2009

IT354 Reinforcement Learning (3-0-2) 4

Introduction to Reinforcement Learning, Markov Processes Markov Reward Processes (MRPs) Markov Decision Processes (MDPs), MDP Policies, Policy Evaluation, Policy Improvement, Policy Iteration, Value operators, Model-free learning - Q-learning, SARSA, Scaling up: RL with function approximation, RL with function approximation, Imitation learning in large spaces, Policy search, Exploration/Exploitation, Meta-Learning, Batch Reinforcement Learning, Bandit problems and online learning, Solution methods: dynamic programming, Monte Carlo learning, Temporal difference learning, Eligibility traces, Value function approximation, Models and planning, Case studies: successful examples of RL systems, Frontiers of RL research

Reinforcement Learning: An Introduction, Sutton and Barto, 2nd Edition.
Reinforcement Learning: State-of-the-Art, Marco Wiering and Martijn van Otterlo, Eds
Artificial Intelligence: A Modern Approach, Stuart J. Russell and Peter Norvig.
Deep Learning, Ian Goodfellow, Yoshua Bengio, and Aaron Courville.

MAJOR PROJECT (MP)

IT448 MAJOR PROJECT – I (0-0-3) 2

The student has to select a project based on a topic of interest before starting of VII semester. This project work will be commencing in VII semester and continued in VIII semester, at the end of each semester, the project will be evaluated internally and externally as per the evaluation criteria decided by the DUGC.

IT498 MAJOR PROJECT – II (0-0-6) 4

The student has to select a project based on a topic of interest before starting of VII semester. This project work will be commencing in VII semester and continued in VIII semester, at the end of each semester, the project work will be evaluated internally and externally as per the evaluation criteria decided by the DUGC.

MANDATORY LEARNING COURSES (MLC)

IT289 SEMINAR 1

This seminar is a 1 credit mandatory learning course to be completed during 4th semester. Each student will make technical presentation on a topic of academic interest as per recommendations and evaluation criteria of the DUGC of IT department.

IT447 PRACTICAL TRAINING 1

The Student has to undergo a practical training programme or carrying out a research/practical oriented project or any equivalent training programme fixed by the DUGC of IT department. This practical training will be done during summer vacation (10-12 weeks) before the evaluation semester. Final evaluation is based on the report/seminar by the student

SA401 Liberal arts courses/cocurricular/extracurricular activities 10

The students are required to earn minimum 10 credits under "Liberal arts courses/cocurricular/extracurricular activities". The Liberal arts courses/cocurricular/extracurricular activities may be categorized as follows:

CATEGORY A: Sports/club activities/organizing Institute level programmes/NSS - Maximum 3 credits may be earned under this category of activities with credit allocation as follows:

- Participation in club activities /NSS/ competitions held by the club –1 credit per participation.
- Member of a Club -2 credits per membership.
- Organizing team members of Institute events like INCIDENT/Engineer /club office bearers -3 credits per membership.
- Participation in state/National /International level competitions/paper presentation/Model building competitions -- 3 credits / participation .
- All the certificates under this category are to be submitted by the student to his/her department at the end of 7thsemester clearly specifying the category for consideration, after approval from Dean (SW) through the faculty advisor for the respective club/Committee.

CATEGORY B: NCC or YOGA courses offered by the Institute - Maximum 3 credits

- Certificates under this category are to be submitted by the student to his/her department at the end of 7th semester clearly specifying the category for consideration, after approval from Dean (SW) through NCC Officer/Yoga Instructor of the Institute, as applicable.

CATEGORY C: Certified courses in Languages /Fine arts - Maximum 7 credits may be earned under this category.

- The certificates issued by the authorized certification bodies to be submitted by the Student to his/her department at the end of 7th semester clearly specifying the category for consideration, after approval from Dean (SW).

The courses/activities under "Liberal arts courses/cocurricular/extracurricular activities" may be taken during the period from 1st semester to 7th Semester B.Tech at student's convenience. However, this course registration to be done in the seventh semester. The certificates must be submitted by the student to the Department at the end of seventh semester with due forwards/ recommendations and approvals from the appropriate authority as specified above along with the credits earned in each category in a prescribed format. The prescribed format for the same will be made available in the Curriculum book. The Departments to send a consolidated grade sheet for all the registered students in a prescribed format. The prescribed format to clearly indicate the Credits earned in each category of this MLC course along with the total credits earned for this course for all the registered students. The prescribed format for the same to be made available in the Curriculum book.

PROGRAMME SPECIFIC ELECTIVES

IT212 Intelligent Data Management (3-0-2) 4

Data Modeling - Designing Logical Data Models - Physical Data Models - Leveraging Data Models-Data relationships - Conceptual Graph - Representing Conceptual Structures - Reasoning with Graphs - Semantic Graph - Relationships between Categorical Variables - Tabular Representation of Associations - Graphical Representation of Associations - Interpretation and Comparison of Results -Datastorage perspectives; Transaction Processing- Basics of Fault Tolerance- Transaction-Oriented Computing - Concurrency and Recovery

John F. Sowa, "Conceptual Graphs Summary," in Conceptual Structures: Current Research and Practice, P. Eklund, T. Nagle, J. Nagle, and L. Gerholz (Eds.), Ellis Horwood, pp. 3-52, 1992.

Jim Gray and Andreas Reuter. 1992. Transaction Processing: Concepts and Techniques *(1st ed.). Morgan Kaufmann Publishers Inc., San Francisco, CA, USA.*

R. Elmasri and S.B Navathe , "Fundamentals of Database Systems", 2000.

IT213 Database Systems (3-0-2) 4

Basic concepts, Data models and languages, Database design (conceptual and physical), System implementation techniques, Current trends in database system, Distributed databases; Design and Implementation of Database systems or packages for applications such as office automation, hotel management, hospital management; deployment of Forms, Reports Normalization, Query Processing Algorithms in the above application projects; Implementation of few important functionalities of relational database management systems

R. Elmasri and S.B Navathe , Fundamentals of Database Systems, The Benjamin/Cummings Publishing Company, 2000

Raghu Ramakrishnan, Database Management Systems, McGraw Hill, 2000

M. Tamer Özsu, Principles of Distributed Database Systems, Prentice Hall, 1999.

Silberschatz, Korth A.F., Sudarshan S., Database System Concepts, McGraw Hill,2005

IT259 Data Visualisation (3-0-2) 4

Overview of visualization, graphics, drawing, photorealism, human perception - Visualization of Numerical Data-Data, mapping, charts, glyphs, parallel coordinates, stacked graphs, Tufte's design rules, using color - Visualization of Non-Numerical Data - Graphs, networks, treemaps, Principle Component Analysis, multidimensional scaling, packing - Visualization systems, Information Visualization, database visualization, visualization system design - - Trends in Data Visualization and Other Tools - Declarative programming, reactive programming.

Visualization Analysis and Design, Tamara Munzner, AK Peters Visualization Series, CRC Press, Nov. 2014

Visualize This: The Flowing Data Guide to Design, Visualization, and Statistics Nathan Yau, Wiley (2011)

Donahue, Rafe. "Fundamental statistical concepts in presenting data: principles for constructing better graphics." (2011).

IT260 Robotics Programming (3-0-2) 4

Introduction to Robotics: Advanced and impressive robots, Robots that look like humans and animals, Robots in the home, Robots in industry, Robot arms, Warehouse robots, Competitive, educational, and hobby robots. Exploring Robot Building Block: Code and Electronics, Types of motors, sensors, and actuators, Status indicators

– displays, lights, and sounds, Controllers and IO. Introducing the Raspberry Pi - Starting with Raspbian, Connectivity and networking, Preparing a Raspberry Pi for a Robot, Building Robot Basics - Wheels, Power, and Wiring Using Python to Control Servo Motors, Programming Distance Sensors with Python, Programming Encoders with Python, Robot Vision - Using a Pi Camera and OpenCV , Voice Communication with a Robot Using Mycroft, Programming a Gamepad on Raspberry Pi with Python

Danny Staple, Learn Robotics Programming, Packt Publishing Ltd., 2018
R Brooks and C Ferrell, Embodied Intelligence, MIT Press
U Nehmzow, Mobile Robotics: A practical introduction, Springer Verlag

IT308 Brain Computer Interfaces (3-0-2) 4

Signal Recording & Stimulation: Recording Signals, Simultaneous Recording & Stimulation; Signal Processing: Frequency Domain Analysis, Fourier Analysis, Discrete Fourier Transforms, Fast Fourier Transforms, Spectral Features, Wavelet Analysis, Time Domain Analysis - Convolution and Correlation, Principal Component Analysis and Independent Component Analysis; Brain Computer Interfaces (BCI): Types, Invasive, Semi-Invasive, Non-Invasive, Stimulating, Bidirectional and Recurrent BCIs, Applications, Medical and Non-Medical, Ethics of BCI.

Rajesh P N Rao, "Brain Computer Interfacing: An Introduction", Cambridge University Press, 2013
Jonathan R Wolpaw, Elizabeth Winter Wolpaw (Eds.), "Brain Computer Interfaces: Principles and Practice", Oxford University Press, 1st edition, 2012.
Desney S Tan, Anton Nijholt (Eds.), "Brain Computer Interfaces: Applying Our Minds to HCI", Springer 2010.

IT355 Autonomous Agents (3-0-2) 4

Agents Overview: Agent definition, agent programming paradigms, Agents Vs objects, mobile agents, Agent frame works, Agent reasoning; Agents Implementation: Processes, threads, Sockets, RPCs – distributed computing, aglets programming – JINI architecture, actors and agents. Multi Agent Systems: Interaction between agents, reactive agents, cognitive agents, interaction protocols, agent coordination, agent negotiation, agent cooperation, agent organization, self –interested agents in electronic commerce applications. Intelligent Software Agents: Interface Agents, Agent Communication Languages, Agent Knowledge Representation, Agent Adaptability, Belief Desire Intension, Mobile Agent, Applications. Agents and Security: Agent Security Issues, Mobile Agents Security, Protecting Agents Malicious Hosts, Untrusted Agents, Black box Security, Authentication for Agents, Security issues for Aglets.

Joseph P. Bigus and Jennifer Bigus, "Constructing Intelligent Agents Using Java: Professional Developer's Guide", Wiley, Second edition, 2001.
Bradshaw, "Software Agents", MIT Press, 2000
Michael Wooldridge, An Introduction to MultiAgent Systems - Second Edition. Wiley, 2009
Roland Siegwart, Illah Reza Nourbakhsh and Davide Scaramuzza, Introduction to Autonomous Mobile Robots - Second Edition. MIT Press, 2011
Rafael H. Bordini, Jomi Fred Hubner and Michael Wooldridge , Programming Multi-agent Systems in AgentSpeak Using Jason. Wiley, 2007

IT356 Natural Language Processing (3-0-2) 4

Introductory concepts of Linguistic systems, Language Modeling and Sequence tagging, Word stemming, tokenization, normalization, Part of Speech tagging, Traditional models of distributional semantics, Unstructured Text Management, Word and Sentence embeddings, n-gram models, Maximum Entropy models, Hidden Markov Models, Viterbi Algorithm, Neural Language Models; Information Extraction, Named Entity Recognition, Relation Extraction; Understanding Semantics, word sense and word similarity, Lesk Algorithm, Wordnets, Topic Modeling, Dialog Systems, Emerging trends, Research issues, challenges, interesting applications in various domains.

Daniel Jurafsky and James H. Martin. "Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech Recognition". Second Edition. Prentice Hall, 2008
Christopher D. Manning and Hinrich Schütze, "Foundations of Statistical Natural Language Processing" MIT Press, 1999
Tanveer Siddiqui, U.S Tiwary, "Natural Language Processing And Information Retrieval", 1st Ed

IT357 Computer Vision (3-0-2) 4

Introduction to Image Processing: Image Formation on Camera, Camera Mechanism, Perspective Transformation, Image Transformations, Concept of convolution, Concept of Masks, Fourier series and Transform. Features and filters: low-level vision, Linear filters, Edges and contours, Binary image analysis, Background subtraction, Texture Motion and optical flow. Grouping and fitting: mid-level vision: Segmentation and clustering algorithms, Hough transform, Fitting lines and curves, Robust fitting, RANSAC, Deformable contours, Interactive segmentation. Multiple views: Local invariant feature detection and description, Image transformations and alignment, Planar homography, Epipolar geometry and stereo, Object instance recognition, Image warphing, Image stitching, Harris corner detection-interest point detection ,SIFT descriptor, Viola Jones Face detector, Cascading Classifiers for detection. Recognition: high-level vision: Basics of Object detection and recognition, Supervised classification algorithms, Deep learning, Convolutional neural networks.

Rick Szeliski "Computer Vision: Algorithms and Applications".
David A. Forsyth and Jean Ponce " Computer Vision: A Modern Approach"

Linda G. Shapiro and George C. Stockman "Computer Vision"
Emanuele Trucco and Alessandro Verri Introductory Techniques for 3-D Computer Vision,.
Richard Hartley and Andrew Zisserman "Multiple View Geometry in Computer Vision".
Richard O. Duda, Peter E. Hart, and David G. Stork" Pattern classification".
Christopher M. Bishop "Pattern Recognition and Machine Learning".
K. Grauman and B. Leibe "Visual Object Recognition".

IT358 Soft Computing (3-0-2) 4

Fuzzy logic: Classical sets and Fuzzy sets, Fuzzy sets operations, Fuzzy relations, Membership functions, Defuzzification, Fuzzy rule based systems. Fuzzy implications. Artificial neural network: Model of a neuron, Learning rules, Activation functions, Single layer perceptron networks, Multilayer feed forward networks, Back-propagation algorithm. Solving optimization problems, Concept of Genetic algorithm -Fitness function, Genetic operators: selection, crossover, mutation. Swarm optimization techniques: Particle swarm optimization and Global swarm optimization. Hybrid of soft computing and machine learning methods: GA-Kmeans, GA based wrapper feature selection method, Fuzzy clustering, Fuzzy classifier, Integration of genetic algorithms with neural networks, Integration of genetic algorithms with fuzzy logic; Multi objective evolutionary algorithm approaches, Applications and Recent Research Trends

Ross T.J., Fuzzy logic with engineering applications-McGraw Hill, 1995
J. M. Zurada, Introduction to artificial neural networks, Jaico publishing, 1997.
Goldberg D., Genetic algorithms- Addison-Wesley, 1st edition,1989.
S. N. Sivanandam, S. N. Deepa, Principles of Soft Computing 2nd edition, Wiley, 2011.
Shishir K. Shandilya, Smita Shandilya, Kusum Deep, Atulya K. Nagar, Handbook of Research on Soft Computing and Nature-Inspired Algorithms, IGI Global, 2017.
Evolutionary Algorithm for Solving Multi-objective, Optimization Problems (2nd Edition), Collelo, Lament, Veldhnizer (Springer)
J. Han and M. Kambar, Data Mining: Concepts and Techniques, Morgan Kaufmann Publishers Elsevier), 2008.

IT359 Pattern Recognition (3-0-2) 4

Introduction to Model Selection, Decision Theory, Information Theory; Linear Models for Regression and Classification, Neural Networks: Network Training, Jacobian/Hessian Matrices, Regularization, Mixture Density Networks, Bayesian Networks; Computational Learning Theory, Kernel Methods, Sparse Kernel Machines, Graphical Models, Markov Random Fields, Expectation Maximization, Approximate Inference, Factorized Distributions, Expectation Propagation, Hidden Markov Models, Linear Dynamical Systems, Hybrid Model Construction- Boosting, Tree-based models, Conditional Mixture Models, Q-learning and Policy Gradient, PR Applications.

Pattern Recognition and Machine Learning, Christopher Bishop, Springer, 2006.
Pattern Classification, Duda, Hart, and Strok, Wiley, latest edition.
Pattern recognition, Theodoridis, Sergios, Koutroumbas, Konstantinos, Elsevier.
Introduction to Neural Networks, Heaton, Jeff, Heaton research, 2nd edition, 2008
Pattern Recognition - Narasimha Murthy and Susheela Devi (Univeristies Press, 2011)

IT367 Information Retrieval (3-0-2) 4

Introduction: Basic Concepts, Information need vs. Query, Modern Search Interface requirements, IR System Architecture, Preprocessing techniques, Tokenizing, Indexing, Classic IR Models for unstructured data, Inverted Index, Vector Space Model, Best Match models, Probabilistic models Implementation of IR models, Structured IR models, Multimedia IR, Experimental Evaluation of IR Systems, Implicit and Explicit Relevance Feedback techniques, Document/Query Properties and Representations, Web Search and Link analysis algorithms, Recommender Systems, Learning to Rank and Learning the ranking function based techniques, Selected research papers on emerging trends and open problems in IR.

C. D. Manning, P. Raghavan and H. Schütze, "Introduction to Information Retrieval",, Cambridge University Press. 2008.
Baeza-Yates & Ribeiro-Neto, "Modern Information Retrieval", Pearson Education, 2010
Donald Metzler, Trevor Strohman, and W. Bruce Croft, "Search Engines: Information Retrieval in Practice", Pearson Education, 2010

IT368 Internet of Things (3-0-2) 4

Principles and foundation of IoT: Reference Models, Platforms, Big data and IoT, Relevance of AI in IoT. IPv6 packet. Communication standards for IoT: IEEE 802.15.4, IEEE 802.11, 6LoWPAN. Routing in IoT, Standards for IoT, 5G. Service Oriented architecture, The Constrained Application Protocol (CoAP) and MQTT: features, interaction model, messages and request and response sub layer. Application of AI in IoT.

Amita Kapoor, Hands on Artificial Intelligence for IoT, Packt>, 2019
J. Biron and J. Follett, Foundational Elements of an IoT Solution, O'Reilly Media, 2016. Keysight Technologies, The Internet of Things: Enabling Technologies and Solutions for Design and Test, Application Note, 2016.
Charles Bell, Beginning Sensor Networks with Arduino and Raspberry Pi, Apress, 2013 Arshdeep Bahga and Vijay Madisetti, Internet of Things: A hands on approach, VPT Publications 2014
Olivier Hersent, David Boswarthick, Omar Elloumi, The IoT: Key Applications and Protocols, Wiley, 2015.

IT369 Performance Modeling (3-0-2) 4

Operational Laws: Little's Law, response-time law, asymptotic bounds, modification analysis, performance metrics; Markov Chain Theory: discrete-time Markov chains, continuous-time Markov chains, renewal theory, time-reversibility; Poisson Process: memorylessness, Bernoulli splitting, uniformity, PASTA; Queueing Theory: open networks, closed networks, time-reversibility, RenewalReward, M/M/1, M/M/k, M/M/k/k, Burke's theorem, Jackson networks, classed networks, load-dependent servers, BCMP result and proof, M/G/1 full analysis, M/G/k, G/G/1, transform analysis (Laplace and z-transforms); Simulations: time averages versus ensemble averages, generating random variables for simulation, Inspection Paradox; Modeling Empirical Workloads: heavy-tailed property, Pareto distributions, heavy-tailed distributions, understanding variability and tail behavior, Matrixanalytic methods; Management of Server Farms: capacity provisioning, dynamic power management, routing policies; Analysis of Scheduling: FCFS, non-preemptive priorities, preemptive priorities, PS, LCFS, FB, SJF, PSJF, SRPT, etc

Mor Harchol-Balter,Performance Modeling and Design of Computer Systems: Queueing Theory in Action, Cambridge University Press.

Papoulis and S. U. Pillai, Probability, Random Variables, and Stochastic Processes, McGraw-Hill.

Leon-Garcia, Probability and Random Processes for Electrical Engineering, Prentice Hall.

Michael Pinedo, Scheduling Theory, Algorithms, and Systems, Prentice Hall.

IT370 Time Series Analysis (3-0-2) 4

Stationary processes, ensemble, random walk Vs trend, periodicity, linear process; Estimators mean, ACF, PACF, variogram ;Properties covariance , normality ; Regression , models for trend, differencing, backshift operator ; Harmonic regression, periodogram, signal processing; Nonparametric regression, smoothing, periodic functions; Model selection, AIC, BIC, SIC, bias-variance trade-off; ARMA models; Estimation , MLE, LS, forward-backward ; State-space models ,Kalman filter, hidden state, HMM, Switching models, hidden Markov models (HMM), GARCH, stochastic volatility, financial models; Heteroscedasticity, Wavelets Vector Autoregressive (VAR) Models, Integrated Variables and Cointegrated VAR Models, Time-varying parameter and Bayesian VARs, Multivariate GARCH Models

Shumway, R.H. and Stoffer, D.S., Time Series Analysis and its Applications: With R Examples, Springer.

Pole A., West M. and Harrison P.J., Applied Bayesian Forecasting and Time Series Analysis. Chapman-Hall.

Tsay, R. S. Analysis of Financial Time Series, John Wiley and Sons .

West, M. and Harrison, P.J. (1997), Bayesian Forecasting and Dynamic Models,Springer-Verlag.

IT371 Operating Systems (3-0-2) 4

Introduction to operating systems, Process concepts, Scheduling algorithms, CPU scheduling, Multithreading models, Concurrent processes, Deadlocks, Virtual and physical memory management, Disk scheduling, File systems; Device Drivers: Building and Running Modules, Char Drivers, Concurrency and Race Conditions, Interrupt Handling, Data Types in the Kernel, Drivers: PCI, USB, Block, Network, TTY Drivers.

Andrew S. Tannenbaum and Herbert Bos, Modern Operating Systems, 4th Edition, Pearson, 2015

Abraham Silberschatz et al., Operating System Concepts, 9th Ed., John Wiley, 2012.

Harvey M. Deitel et al., Operating System, 3rd Edition, Pearson, 2007.

William Stallings, Operating Systems: Internals and Design Principles. 9th Ed., Pearson, 2017.

M. J. Bach. Design of the Unix Operating System, 1st Edition, Pearson, 2015.

Jonathan Corbet et al., Linux Device Drivers, 4th Edition, O'Reilly, 2013.

IT424 Computational Auditory Perception (3-0-2) 4

Cognitive Neuroscience: Mind and Brain, Structure and Function of the Brain Nervous System, Methods of Cognitive Neuroscience, Hemispheric Specialization, Sensation and Perception, Object Recognition, Attention, Action, Learning and Memory, Emotion, Thinking and Problem Solving, Language, Cognitive Control, Social Cognition, Consciousness.

Michael S. Gazzaniga, Richard B. Ivry, George R. Mangun, "Cognitive Neuroscience: The Biology of the Mind", W. W. Norton & Company; Fifth Edition, December 1, 2018.

Bernard J Baars, Nicole M Gage, "Cognition, Brain and Consciousness: Introduction to Cognitive Neuroscience", Academic Press and Elsevier Ltd., 2nd Edition, 2010.

Michael S. Gazzaniga (Ed.), "The Cognitive Neurosciences", The MIT Press, 4th Edition, 2009.

IT425 Computational Visual Perception (3-0-2) 4

Fundamentals of Image and Video Processing; Image and Video Analysis: Image Transforms - DCT, Hadamard, Haar, KL and Wavelets; Image and Video Compression Standards: JPEG, JPEG2000, MPEG1, MPEG2, MPEG4 & MPEG7; Image and Video Rendering and Assessment; Human Visual Perception; Perceptual Video Quality Metrics, Perceptual Coding and Processing of Digital Pictures; Image and Video Storage, Retrieval; Applications and Research Trends.

Perceptual Based Image Processing, Morgan & Claypool, 2009

Al Bovik, "Handbook of Image and Video Processing", Elsevier Academic Press, 2005

H. R. Wu and K. R. Rao, "Digital Video Image Quality and Perceptual Coding", CRC Press, 2005

R. C. Gonzalez and R E Woods, "Digital Image Processing", Pearson Education, 2002

William K Pratt, "Digital Image Processing", Wiley, 2001.

IT426 Smart Systems Development (3-0-2) 4

Introduction to Smart Systems, need, Architecture, Infrastructure, Design challenges, Research Challenges. Fundamentals of Smart Infrastructure. Smart Cities, Smart Mobility. Challenges, Architecture, Design of systems in Smart Transportation, Smart Building and Home Devices, Smart health, Smart Government, Smart Energy and Water. Cybersecurity, safety and privacy for smart cities, Applications of IoT, Blockchain, AI and virtual reality in Smart environments.

Carol L. Stimmel, Building Smart Cities: Analytics, ICT, and Design Thinking , CRC press 2015
Lukas Neckermann, Smart Cities, Smart Mobility: Transforming the Way We Live and Work, 2017
Houbing Song, Ravi Srinivasan, Tamim Sookoor, Sabina Jeschke, Smart Cities: Foundations, Principles, and Applications, 2017, Wiley
Amitabh Satyam and Igor Calzada , The Smart City Transformations: The Revolution of The 21st Century, Bloomsbury 2017

IT427 Genetic Algorithms (3-0-2) 4

Introduction, Possible Applications, Pros and Cons, Principles of Evolutionary Processes and Genetics Introduction to Evolutionary Computation: Biological and artificial evolution, evolutionary computation and AI, different historical branches of EC, a simple genetic algorithm. Search Operators: Crossover, mutation, crossover and mutation rates, Crossover for real-valued representations, mutation for real-valued representations, combinatorial GA, Selection Schemes: Fitness proportional selection and fitness scaling, ranking, tournament selection, selection pressure and its impact on evolutionary search. Theoretical Analysis of Evolutionary Algorithms: Schema theorems, convergence of the algorithms, computational time complexity of the algorithms, no free lunch theorem. Search Operators and Representations: Mixing different search operators, adaptive representations. Niching and Speciation: Fitness sharing, crowding and mating restriction. Constraint Handling: Common techniques, penalty methods, repair methods, Deb's penalty parameter method. Multiobjective evolutionary optimization: Pareto optimality, multi-objective evolutionary algorithms: MOGA, NSGA-II, etc. Applications of GA in engineering problems, job-shop scheduling and routing problems. Evolutionary robotics and evolutionary hardware: Evolving control. Evolving morphology. Body-brain co-evolution. Evolution in simulation and in reality. The case for and against simulation.

Goldberg D.E. Genetic Algorithms in Search, Optimization and Machine Learning. Pearson Education Asia 2002
K. Deb, Multi-Objective Optimization Using Evolutionary Algorithms, Wiley and Sons, 2009.
M. Mitchell, An introduction to genetic algorithms, MIT Press, 1996.
L. D. Davis, Evolutionary algorithms, Springer-Verlag, 1999.
Evolutionary Computation: A Unified Approach by Kenneth A. DeJong, MIT Press, 2006, ISBN: 0262041944
Bäck, T, 2000. Evolutionary Computation 1: Basic Algorithms and Operators. Institute of Physics Publishing, Bristol.
Jacob, C., 2001. Illustrating Evolutionary Computation with Mathematica. Morgan Kaufmann.

IT428 Industry 4.0 (3-0-2) 4

Introduction to smart manufacturing, Digitalisation and the Networked Economy; Drivers, Enablers, Compelling Forces and Challenges for Industry 4.0, Driving technologies - Internet of Things (IoT), Industrial Internet of Things (IIoT), Internet of Services, Numerical control (NC), NC programming, Robot programming and PLC, Process plan representation models (for automation), Cyberphysical Systems, Robotic Automation and Collaborative Robots, Cyber Security for smart Industry systems, Autonomous Decision Support Systems for Industry 4.0, Predictive Analytics, Trends of Industrial Big Data and Predictive Analytics for Smart Business Transformation, Case studies – Toyota, Autoliv, Tesla Production Systems, Mega Factories, Smart City case studies.

Industry 4.0: The Industrial Internet of Things, Alasdair Gilchrist, Apress Publishers 2017
Enterprise IoT: Strategies and Best Practices for Connected Products and Services - Dirk Slama, Frank Puhlmann , Jim Morrish , Rishi M. Bhatnagar, O-Reilly Media (2015)
Hands-On Industrial Internet of Things Paperback - Giacomo Veneri Antonio Capasso, Packt Books (2018)
Quick Start Guide to Industry 4.0: One-stop reference guide for Industry 4.0, Pabbathi (2018)

IT429 Number Theory and Cryptography (3-0-2) 4

Elementary number theory, Finite fields, Arithmetic and algebraic algorithms, Secret key and public key cryptography, Pseudo random bit generators, Block and stream ciphers, Hash functions and message digests, Public key encryption, Probabilistic encryption, Authentication, Digital signatures, Zero knowledge interactive protocols, Elliptic curve cryptosystems, Formal verification, Hard problems, Randomness and Pseudo randomness & Testing.

Koblitz, N. "Course on Number Theory and Cryptography", Springer Verlag, 1986
Alfred J. Menezes, Paul C. van Oorschot and Scott A. Vanstone. "Handbook of Applied Cryptography", CRC Press, 1996, Fifth Printing (August 2001).
William Stallings "Cryptography and Network Security: Principles and Practice", Sixth Edition, Pearson Publisher.

Behrouz A Forouzan and Debdeep Mukhopadhyay, "Cryptography and Network Security", Mc Graw Hill Education Publisher.

IT430 Quantum Cryptography (3-0-2) 4

Introduction to Quantum Computation: Quantum bits, Bloch sphere representation of a qubit, multiple qubits, XOR of Bit sequence, design of quantum circuits, Introduction to Cryptography, Cryptography with XOR, Shared Secret, Importance of Randomness, Breaking the Code, Comparison between classical and quantum information theory, Bell states, Quantum teleportation, Principles of Quantum Cryptography, Quantum key distribution, Single photons, EPR pairs, no cloning theorem. Quantum Algorithms, BB84 Protocol, Error Correction: Graph states and codes, Quantum error correction, fault- tolerant computation.

Nielsen M. A., Quantum Computation and Quantum Information, Cambridge University Press.
Benenti G., Casati G. and Strini G., Principles of Quantum Computation and Information, Vol. II, Basic Concepts, Vol II: Basic Tools and Special Topics, World Scientific.
Pittenger A. O., An Introduction to Quantum Computing Algorithms
Bellac Michel Le, "A short introduction to quantum information and quantum computation", Cambridge University Press, 2006
N. David Mermin, "Quantum Computer Science" ,Cambridge University Press, 2007.

IT431 Distributed Computing (3-0-2) 4

Basic concepts - Computer networks, Distributed systems and Computing, Design goals, Fundamental Issues in Distributed Systems, Distributed System Models and Architectures; Classification of Failures in Distributed Systems, Basic Techniques for Handling Faults in Distributed Systems; Logical Clocks and Virtual Time; Physical Clocks and Clock Synchronization Algorithms; Security Issues in Clock Synchronization; Transparencies in DCS, Ordering of events, Ordering of messages and concerned protocols, Global state detection Process synchronization, Process communications, Load balancing techniques.

Mukesh Singhal and Niranjan G. Shivaratri, Advanced Concepts in Operating System, Tata McGraw Hill, 1994.
A.S Tanenbaum and M.V. Steen, Distributed Systems – Principles and Paradigms, Prentice-Hall, 2006.
Randy Chow, Distributed Operating Systems and Algorithms, Addison Wesley, 1997.
G.F. Coulouies, J.D. Dollimore and T. Kindberg, Distributed Systems: Concepts & Design, Addison Wesley, 1994.

IT432 Computational Photography (3-0-2) 4

Camera geometry and optics, Focus and depth, Computational apertures and shutters, Exposure and high dynamic range, Flash / no flash photography, Super-resolution and denoising. Photo quality assessment, Image filtering and image pyramids, Image blending and compositing Texture synthesis and inpting, non photorealistic rendering Single / multi view reconstruction, Image based lighting and rendering

Barbara London and John Upton, "Photography".
Richard Szeliski,"Computer Vision: Algorithms and Applications".
Richard Hartley and Andrew Zisserman, "Multiple View Geometry in Computer Vision".
David Forsyth and Jean Ponce, "Computer Vision: A Modern Approach".
Steven Gortler, "Foundations of 3D Computer Graphics".
Rafael Gonzalez and Richard Woods, "Digital Image Processing".

IT433 Blockchain Technology (3-0-2) 4

Blockchain Architecture, P-2-P Networks, Blockchain Networks, Transaction Life Cycle, Role of Miners in Blockchain Technology, Consensus Algorithms, Proof of Work, Proof of Stake, Proof of Elapsed Time, Round Robin-Advantages and Disadvantages, Candidate Blocks, Blockchain Technology and Artificial Intelligence, IoT and Blockchain: Challenges and Risks, Introduction to Blockchain and IoT, Challenges of Blockchain in IoT, Risks of using Blockchain in IoT, The optimum Secure IoT Model, Blockchain in Intelligent Vehicles, Blockchain Technology for Supply Chain Insight from Enterprise Resource Planning, Next Generation Blockchain Enterprise Artificial Intelligence System, Artificial Intelligence and Deep Learning Chains, Blockchain Technology Use Cases in Health Care, Blockchain Technology Use Case in Smart City Applications. Blockchain Hands on for generating Genesis Block.

"Advanced Applications of Blockchain Technology", Shiho Kim and Ganesh Chandra Deka, Springer , 2019, (Available Online)
Blockchain Technology: Platforms , Tools and Use Cases " Advances in Computers Volume 111, Ali R Hurson and Atif M. Memon, Academic Press, 2019.
"Secure and Smart Internet Of Things (IoT) using Blockchain and Artificial Intelligence" , Ahmed Banafa , 2018

IT434 Digital Forensics (3-0-2) 4

Introduction, The Scope of Computer Forensics, Windows Operating and File Systems, Handling Computer Hardware, Acquiring Evidence in a Computer Forensics Lab, Online Investigations, Documenting the Investigation, Admissibility of Digital Evidence, Network Forensics, Mobile Forensics, Photograph Forensics, Mac Forensics. Database forensics: forensic study of databases and their metadata. Investigative use of database contents, log files and in-RAM data in order to build a time-line or recover relevant information. Mobile device forensics: recovery of digital evidence or data from a mobile device. Media Analysis: disk structure, file systems (NTFS, EXT 2/3, HFS), and physical layer issues; Tools for digital forensics. Analysis Techniques: keyword

searches, timelines, hidden data; Application Analysis; Network Analysis; Analysis of Cell phones, PDAs, etc.; Binary Code Analysis; Evidence: collection, preservation, testimony.

Dr. Darren R. Hayes, "A Practical Guide to Computer Forensics Investigations", Pearson Publisher
Kanellis, Panagiotis, "Digital Crime and Forensic Science in Cyberspace", IGI Publishing", ISBN 1591408733.
Jones, Andrew (2008), "Building a Digital Forensic Laboratory. Butterworth Heinemann", ISBN 1856175103.
Marshell, Angus M. (2008), "Digital Forensics: Digital Evidence in Criminal Investigation", Wiley Blackwell, ISBN 0470517751
Philip Craiger, Sujeet Shenoi, "Advances in Digital Forensics in", Springer, 2007.
Paul Crowley Dave Kleiman, "CD and DVD Forensics", Syngress Publishing Inc, 2007.
Chris Prosise, Kevin Mandia, "Incident Response & Computer Forensics", McGraw-Hill, 2 nd Edition, 2003.

IT435 Computational Biology (3-0-2) 4

Introduction to Bioinformatics, Biological Databanks,Biological Sequence Analysis: Genome-Microarray, pairwise sequence alignment, Dynamic programming, global and local alignment, Progressive multiple sequence alignment, Iterative multiple sequence alignment. BLAST Scoring matrices, gap penalty, statistical significance of multiple sequence alignment, sum-of-pairs method, CLUSTAL W, searching motifs in sequence alignment. Phylogentics – distance-based using UPGMA, Neighbour Joining. Protein Structure prediction – Secondary Structure prediction, Protein Secondry Structural Class prediction, Protein Fold recognition, Protein Tertiary Structure prediction. Protein-Protein Interaction, Protein Subcellular Localization, Emerging Areas in Bioinformatics.

Durbin, R., Eddy, S., Krough, A. & Mitchison, G. (1998). Biological sequence analysis: probabilistic models of proteins and nucleic acids. Cambridge University Press.
Jones, N.C. & Pevzner, P.A. (2004). An introduction to bioinformatics algorithms. MIT Press.
Bioinformatics: Sequence and Genome Analysis by David Mount, Cold Spring Harbor Laboratory Press (2001)
Biological Sequence Analysis: Probabilistic models of proteins and nucleic acids by R. Durbin, S.Eddy, A. Krogh and G. Mitchison, Cambridge University Press (1998)
Knowledge Discovery in Bioinformatics: Techniques, Methods, and Applications by Xiaohua Hu and Yi Pan, John Wiley & Sons (2007)
A Metaheuristic Approach to Protein Structure Prediction by Jana, Nanda Dulal, Das, Swagatam, Sil, Jaya, Springer (2018)

IT436 Cloud Computing (3-0-2) 4

Concept of cloud computing and evolution. Define SLAs and SLOs and illustrate their importance in Cloud Computing, Threats in cloud security, Common cloud providers and their associated cloud stacks and popular cloud use case scenarios. Cloud infrastructure: Cloud Reference Architecture. Cloud software deployment considerations such as scaling strategies, Load balancing, Fault tolerance, and Optimizing for cost. Cloud resource management: Virtualizing CPUs, full virtualization, Para-virtualization, and Memory virtualization. Cloud storage: Organization of data and storage. HDFS, Google GFS, Big-Table. Programming models: Fundamental aspects of parallel and distributed programming models. Cloud programming models (Map reduce, Spark, Graph Lab and Spark Streaming). Map-reduce programming model.

Anthony T Velte, Cloud Computing: A Practical Approach, McGraw Hill,2010
J. Lin and C. Dyer, Data Intensive Text Processing with MapReduce, , Morgan and Claypool, 2010
T. Velte, A. Velte, R. Elsenpeter, Cloud Computing, A Practical Approach, McGraw Hill, 2009
Rajkumar Buyya, James Broberg, Andrzej M., Cloud Computing: Principles and Paradigms, Wiley, 2010.
Dan Marinescu, Cloud Computing:Theory and Practice , Morgan Kaufmann, 2013

IT437 Quantum Computing (3-0-2) 4

History of quantum computation and quantum information, Future directions, Basic Mathematics: Linear operators and matrices, Tensor products, Operator functions. Quantum Logics: QISKIT, Introduction to Qubit, Single qubit operation, Multiple Qubit operation, Single qubit gates, Multiple qubit Gates, Controlled Not gate, Swap gate, Toffoli gate, Universal quantum gates. Quantum Algorithms and Applications: The quantum search algorithm, Quantum search as a quantum simulation, Quantum counting, Speeding up the solution of NP complete problem, Quantum search of an unstructured database, Optimality of the search algorithm.

Michael. A. Nielsen and I. L. Chuang, Quantum Computation and Quantum information, Cambridge University Press 2000.
Bellac Michel Le, "A short introduction to quantum information and quantum computation", Cambridge University Press, 2006
Vishal Sahni, "Quantum Computing", Tata McGrawHill, 2007.
Richard L. Liboff, Introductory Quantum Mechanics, Pearson, Fourth Edition (2003).
QISKIT textbook: https://qiskit.org/textbook/content/ch-ex/

IT438 Big Data Analytics (3-0-2) 4

Introduction– distributed file system–Big Data and its importance, Four Vs, Drivers for Big data, Algorithms using map reduce, Apache Hadoop & Hadoop EcoSystem, Data Serialization, HDFS, Hive Architecture, HiveQL Querying Data, Sorting And Aggregating, Map Reduce Scripts, Joins & Sub queries, HBase concepts, Schema Design, Advance Indexing, PIG, Zookeeper , Data Analysis with Spark, Programming with RDDs, Machine

Learning with MLlib, NoSQL, NewSQL, Creating and Querying through Indexes, Document-Oriented, principles of schema design, Constructing queries on Databases, collections and Documents, MongoDB Query Language, Big data analytics, Big data applications.
Understanding Big data, Chris Eaton,Dirk derooset al, McGraw Hill, (2017)
Big Data and Analytics, 2ed, Subhashini Chellappan Seema Acharya, Wiley (2019)
Big Data: Principles and Best Practices of Scalable Real-Time Data Systems - Nathan Marz and James Warren, Manning Publishers (2015)

IT439 Sentiment Analysis (3-0-0) 3

Introduction to Sentiment, Subjectivity, and Stance; Overview, From Words to Discourse & Pragmatics, From Text to Tweets to Speech, Joint Models, Recognizing Stances, Arguments, and Viewpoints, Lexicon-based approaches to sentiment analysis, Exploiting dictionaries, Ontologies, Specialized corpora for detecting the sentiment polarity in texts, Machine learning approaches to sentiment analysis, Sentiment and polarity detection as a classification problem. Neural network architectures for sentiment analysis, Neural network for sentiment detection and polarity evaluation, Affect and emotion detection in texts., Methods and techniques for modeling the language of emotions using neural networks and statistical language models., Exploitation of multimodal data in combination with text to detect the language of emotions, Applications and case studies.
Opinion mining and sentiment analysis, Bo Pang and Lillian Lee, Foundations and Trends in Information Retrieval 2(1-2), pp. 1-135, 2008.
Sentiment Analysis and Opinion Mining, Bing Liu, Morgan and Claypool Publishers, 2012.
Sentiment Analysis: Mining Opinions, Sentiments, and Emotions -Bing Liu , Cambridge University Press, 2015
Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition, 2nd edition, by Daniel Jurafsky and James Martin. (J&M)

IT442 Autonomous Cyber Physical Systems (3-0-0) 3

CPS architecture. Overall architecture for CPS. Mobile sensing devices and platforms for CPS. Naming, addressing, and profile services for CPS. Device search and selection for CPS. Energy management for CPS. Enabling technologies for CPS. Networking technologies for CPS. Machine-to-machine communications for CPS. Mobile cloud computing for CPS. CPS applications. Connected healthcare for CPS. Multi-player gaming for public transport crowd. Mobile cloud computing enabled emerging CPS applications.
Chi (Harold) Liu, Yan Zhang, "Cyber Physical Systems: Architectures, Protocols and Applications", 1st Edition, CRC Press, Published September 19, 2019
Rajeev Alur. Principles of Cyber-Physical Systems. The MIT Press, 2015.
K. J. Astrom and R. M. Murray. Feedback Systems: An Introduction for Scientists and Engineers. Prince- ton University Press, 2009. http://www.cds.caltech.edu/~murray/amwiki/index.php/Main_Page.
C. Baier and J.-P. Katoen. Principles of Model Checking. The MIT Press, 2008.
H. Choset, K. M Lynch, S. Hutchinson, G. Kantor, W. Burgard, L. E. Kavraki, and S. Thrun. Principles of Robot Motion: Theory, Algorithms, and Implementations. MIT Press, 2005.
S. M. LaValle. Planning Algorithms. Cambridge University Press, 2006.
Edward A. Lee and Sanjit A. Seshia, Introduction to Embedded Systems, A Cyber-Physical Systems Approach, Second Edition, 2015.

IT443 Stochastic Processes (3-0-2) 4

Discrete-time Markov chains: Definition and examples of discrete-time Markov chains, Chapman-Kolmogorov equations, Long run behaviour of Markov chains, Absorption probabilities and expected times to absorption, Statistical aspects of Markov chains, The mover-stayer model, Application of a Markov chain and mover-stayer model to modelling.Continuous-time Markov chains: Definition of a continuous-time Markov chain and examples, Poisson process, The Kolmogorov differential equations, Limiting behaviour of continuous-time Markov chains, birth and death processes, Statistical aspects and applications of continuous-time Markov chains. Discrete-time martingales: Conditional expectation, Definition of a martingale and examples, Optional stopping theorem, Applications to random walks, Martingales in option pricing- a simple example; Brownian Motion and its generalizations: Motivation, definition and properties of Brownian motion, Geometric Brownian motion, Continuous-time martingales, Optional stopping theorem;Stochastic calculus: Stochastic integration, Ito's formula, Black-Scholes option pricing formula
Introduction to Probability and Stochastic Processes with Applications, Castaneda, Arunachalam, Dharmaraja, Wiley, 2012
G.F. Lawler, Introduction to Stochastic Processes (Second Edition), Chapman and Hall, Probability Series, 2006.
An Introduction to Stochastic Modeling, H.M. Taylor and S. Karlin, Academic Press, Third Edition

IT445 User Experience Design (3-0-2) 4

UI/UX Overview: Intro to UI/UX,Finding bad UI/UX design; Design: Introduction,Design Toolkit and UI/UX Notebook;User Research:How to identify stakeholders, Defining stakeholders, How to identify user needs,Creating UX Flows,User Journeys:Mapping the user journey, Finding solutions & constraint cards, User Experience Design techniques such as scenarios, personas, storyboards, wireframing, and information architecture; UX Principles: Present Sketches, UX Principles, Converting Sketches to Grayscales, Psychology of UX; User Testing:Understanding user testing, Prepare grayscales for user testing, think aloud testing; UI Principles:layout

and alignment, Finding good UI, color and text,Visual Design Specification;UI Components: buttons, icons, controls, prototyping.

Interaction Design: Beyond Human-Computer Interaction, by Rogers, Sharp, and Preece, ISBN-10 # 0470665769
The Design of Everyday Things, by Norman, ISBN-10 # 0465050654
Sketching User Experiences: Getting the Design Right and the Right Design, by Buxton, ISBN-10 # 0123740371
Designing for Small Screens: Mobile Phones, Smart Phones, PDAs, Pocket PCs, Navigation Systems, MP3 Players, Game Consoles, by Studio 7.5, Zwick, and Schmitz, ISBN-10 # 2940373078

IT469 AI in Healthcare (3-0-2) 4

Introduction to medical informatics, Healthcare data sources and basic analytics, Electronic Health Records, Coding Systems, Modalities - Biomedical image analysis, Genomic data analysis, Natural Language Processing and Data Mining for Clinical Text, mining information from clinical text, dealing with medical terminology, MeSH, SNOMED-CT, Advanced Clinical Data Analytics – Clinical Prediction models, supervised and unsupervised applications, Survival models, evaluations and validation, temporal analytics for clinical data, visual analytics for clinical data, Pervasive health, Clinical Decision Support Systems, Towards explainable-AI in medicine, Applications of Big Data and ML in Medical Diagnostics, Case studies and state-of-the-art systems.

Healthcare Data Analytics (Chapman & Hall/CRC Data Mining and Knowledge Discovery Series) Hardcover – Chandan K. Reddy and Charu C. Aggarwal , CRC Press (2015)
Healthcare Information Management Systems: Cases, Strategies, and Solutions - Charlotte A. Weaver, Marion J. Ball, et al. 2015
Medical Informatics, e-Health: Fundamentals and Applications - Alain Venot, Anita Burgun, et al. 2016
Medical Informatics: Computer Applications in Health Care and Biomedicine - Edward H. Shortliffe and Leslie E. Perreault (2001)

IT471 Cyber Security (3-0-2) 4

Digital Securities: Introduction, Types of Attacks, Digital Privacy, Online Tracking, Privacy Laws, Types of Computer Security risks (Malware, Hacking, Pharming, Phishing, Ransomware, Adware and Spyware, Trojan, Virus, Worms, WIFI Eavesdropping, Scareware, Distributed Denial-Of-Service Attack, Rootkits, Juice Jacking), Antivirus and Other Security solution, Password, Secure online browsing, Email Security, Social Engineering, Secure WIFI settings, Track yourself online, Cloud storage security, IoT security, Physical Security Threads. Online Anonymity: Anonymous Networks, Tor Network, I2P Network, Freenet, Darknet, Anonymous OS – Tails, Secure File Sharing, VPN, Proxy Server, Connection Leak Testing, Secure Search Engine, Web Browser Privacy Configuration, Anonymous Payment: Cryptography and Secure Communication: The Difference Between Encryption and Cryptography, Cryptographic Functions, Cryptographic Types, Digital Signature, The Difference Between Digital Signatures and Electronic Signatures, Cryptographic Systems Trust Models, Create a Cryptographic Key Pair Using Gpg4win/gpg4usb, Disk Encryption Using Windows BitLocker, Disk Encryption Using Open Source Tools, Multitask Encryption Tools, Attacking Cryptographic Systems, Countermeasures Against Cryptography Attacks, Securing Data in Transit, Cloud Storage Encryption, Encrypt DNS Traffic and Email communication, Secure IM and video calls. Cyber Crime Issues and Investigation: Unauthorized Access, Computer Intrusions, White collar Crimes, Viruses and Malicious Code, Internet Hacking and Cracking, Virus Attacks, Pornography, Software Piracy, Intellectual Property, Mail Bombs, Exploitation, Stalking and Obscenity in Internet, Digital laws and legislation, Law Enforcement Roles and Responses, Investigation Tools, eDiscovery, EDRM Model, Digital Evidence Collection, Evidence Preservation, E-Mail Investigation, E-Mail Tracking, IP Tracking, E-Mail Recovery, Hands on Case Studies, Search and Seizure of Computers, Recovering Deleted Evidences, Password Cracking.

Nihad Hassan, Rami Hijazi, "Digital Privacy and Security Using Windows: A Practical Guide" Apress.
"Network Security Essentials", William Stallings, 4th Edition, Pearson Education, 2008.
"Internet and Intranet Security", Rolf Oppliger, 2nd Edition, Artech House, 2007.
"Applied Cryptography, Code Complete, Secure Programming", Articles and papers from http://securityresearch.in.
"Fundamental Problems in Provable Security and Cryptography", Alexander W. Dent (Research Paper).
"Cryptography: An Introduction", Nigel Smart, 3rd Edition, Mcgraw-Hill, 2013.
"Cryptography and Network Security", Behrouz A Forouzan/ Mukhopadhyay, 3rd Ed., McGraw-Hill, 2015.

IT472 Computer Networks (3-0-0) 3

Introduction to computer networks and Internet; Understanding of network and Internet, The network edge, The network core, Understanding of Delay, Loss and Throughput in the packet switching network, protocols layers and their service model, History of the computer network. The Link layer and Local area networks: Introduction and link layer services, error-detection and correction techniques, Multiple access protocols, addressing, Ethernet, switches. Network Layer: Introduction, Virtual and Datagram networks, study of router, IP protocol and addressing in the Internet, Routing algorithms, Broadcast and Multicast routing. Transport Layer: Introduction and transport layer services, Multiplexing and Demultiplexing, Connection less transport (UDP), Principles of reliable data transfer, Connection oriented transport (TCP), Congestion control. Application Layer: Principles of computer applications, Web and HTTP, E-mail, DNS, Socket programming with TCP and UDP.

Kurose and Ross, "Computer Networking- A Top-Down Approach", 6th Edition, Pearson
Andrew S Tanenbaum, "Computer Networks", 4th Edition, Prentice Hall

Behrouz A Forouzan, "Data Communications and Networking", 4th Edition, McGraw Hill

IT473 Cognitive Networks (3-0-2) 4

Cooperative and Cognitive Networks Introduction, Adaptive Networks, Dynamic Factors, Network Functions, Representative Adaptive Techniques, , Self Managing Networks, Concepts and Challenges, Theories for designing Self Management Networks, Self Management Intelligence, Machine Learning for Cognitive Networks-Technology Assessment and Research Challenges, Evolution of Adaptive Systems, Biologically Inspired Networking, Principles, Evolutionary and Adaptive Systems, Swarm Intelligence, Cross-Layer Design and Optimization in Wireless Networks, Cognitive Radio Architecture, Cognitive Ad hoc Networks, Distributed Learning and Reasoning in Cognitive Networks – Methods and Design Decisions, applying Evolutionary Approaches for Cooperation in Networks, Intelligence in Router and Switches,

"Cognitive Networks Towards Self Aware Networks" Qusay H Mahmoud, Wiley Publications, 2007
"Cognitive Wireless Networks: Concepts, Methodologies and Vision Inspiring the Age of Enlightenment of Wireless Communications" , Frank H.P. Fitzek and Marcos D. Katz, Springer, 2007
"CISCO Router and switch Forensics Investigating and Analyzing Malicious Network Activity" Dale Liu, Singress Publicatins, 2009.

IT474 Formal Languages & Automata Theory (3-0-0) 3

Formal Languages and Automata Theory: Generative grammar, Chomsky hierarchy, Finite state Automata: Definition, Concept of Non-determinism, Equivalence of deterministic and Non-deterministic Automata, regular languages; Closure properties. Pushdown Automata: Definition, Equivalence between NPDA and context free grammars, Pumping Lemma for C.F.L's, Decision problems, Closure properties. Turing machines: Definition, extension to Turing machines: Multi-track, Multi-tape, and Non determinism. TM as an acceptor, TM as a computing device; P, NP, NP-Hard & NP-Complete problems

J.E.Hopcroft and J.D.Ullman, Introduction to automata, Languages and computation, Addison Wesley.1969
M. Sipser, Theory of Computation, Cengage, 2013.
H.E.Lewis and C.H. Papadimitiou, Elements of the Theory of Computation, Prentice-Hall of India, 1981.
Derickwood, Theory of Computation, John Wiley & Sons, 1987.

IT475 Computer Organisation and Architecture (3-0-0) 3

Introduction to computer organization and architecture, CPU Organization, Data Representation, Instruction Sets, Data path design, Fixed point and floating point arithmetic operations and hardware design, ALU design, Micro-Operation, Microarchitecture and Instruction Set Architecture, Control unit and Design, Hardwired control unit and Micro programmed control unit, Horizontal micro-programmed and Vertical micro-programmed control unit, Memory organization, Cache memory, Multilevel Cache Organisation, Virtual memory, Input output Unit: Priority Interrupts, Programmed Controlled I/O Transfer, Interrupt controlled I/O transfer, DMA controller, Secondary storage and type of storage devices, Introduction to solid-state drive (SSD), Read and Write operations in memory, Pipelining. Performance evaluation.

Carl Hamacher et al., Computer Organization and Embedded Systems, Sixth Edition, McGraw-Hill, 2014.
Vincent P Heuring, Harry F Jordan, T. G. Venkatesh, Computer Systems Design and Architecture, Pearson, 2008.
Murdocca and Heuring, Computer Architecture & Organization An Integrated Approach, Wiley, 2007.
Hennesy and Patterson, Computer Architecture –A Quantitative Approach, 6th Ed., Morgan Kaufmann, 2017.

IT476 Human Centered Computing (3-0-2) 4

Overview of Human Physiology, Psychology and Usability Factors; Immersive Reality Technologies, Virtual Reality, Augmented Reality and Mixed Realty Systems Design, Prototyping, Framework for Evaluating the Current and Emerging Immersive Reality Technologies and Applications; Design and Technological Foundations for Immersive Experiences; Input Devices – Controllers, Motion Trackers and Motion Capture Technologies for Tracking, Navigation: Touch, Gesture and Marking, Speech, Language and Audition Control; Output Devices – Head Mounted VR Displays, Augmented and Mixed Reality Glasses; 3D Interfaces: Interactive & Procedural Graphics; Immersive Surround Sound; Haptic and Vibrotactile Devices; Systems Architecture and Integrative Immersive Media Platforms; Rapid Prototyping and Physical Computing, VR programming.

Kelly S. Hale, Kay M. Stanney (Eds.), "Handbook of Virtual Environments: Design, Implementation, and Applications", CRC Press, Second Edition, 2015.
Jason Jerald, "The VR Book: Human-Centered Design for Virtual Reality", Association for Computing Machinery and Morgan & Claypool Publishers, 2015.
Bowman, Doug A.; Kruijff, Ernst; LaViola Jr., Joseph J.; Poupyrev, Ivan, "3D User Interfaces: Theory and Practice", Addison-Wesley, 1st Edition, 2005.

IT477 Digital System Design (3-0-2) 4

Introduction: Number Systems and Codes; Boolean Algebra and Logic Gates; Karnaugh Maps and Gate-Level Minimization; Combinational Logic Design: Adders, Subtractors, Comparators, Decoders, Encoders, Multiplexers; Sequential Logic Design: latches, Flip-Flops; Registers, Counters and Memory Unit: Shift Registers, Ripple and Synchronous Counters, Random Access Memory; Algorithmic State Machines; Design at the Register Transfer Level; Hardware Descriptive Language.

M. Morris Mano, Digital Logic & Computer Design, 1st Edition, Pearson Education, 2016.

M. Morris Mano and Michael D. Ciletti, Digital Design with VERILOG HDL, 5th Ed., Pearson, 2012.
Mark Zwolinski, Digital System Design with VHDL, 2nd Edition, Pearson, 2004.
B. Holdsworth and R.C. Woods, Digital Logic Design, 4th Edition, Elsevier, 2003

IT478 Data Mining (3-0-2) 4

Introduction to data mining: Motivation and significance of data mining, Data mining on what kind of data? , data mining functionalities, interestingness measures, classification of data mining system, major issues in data mining; Data pre-processing: Need, data summarization, data cleaning, data integration and transformation, Attribute subset selection methods: filter based and wrapper based methods, Information gain based, correlation based, Minimum redundancy maximum relevance based methods, data discretization and concept hierarchy generalization. Data warehouse and OLAP technology: multidimensional data model(s), data warehouse architecture, OLAP server types, data warehouse implementation, on-line analytical processing and mining; Data cube computation and data generalization. Mining frequent patterns, associations and correlations: Basic concepts, efficient and scalable frequent itemset mining algorithms: A-priori and FP Tree methods, mining various kinds of association rules – multilevel and multidimensional, association rule mining versus correlation analysis, constraint based association mining; Colossal item set Mining: Enumeration methods, Dynamic switching method, parallel method, sequential pattern mining; Bayesian classification, associative classification, lazy learners, grid based and density based clustering methods, Clustering high dimensional data; Data mining on complex data and applications: Algorithms for mining multimedia data, text data, multimodal data, biological sequence data; Data mining applications and trends in data mining.

Han, J. and Kamber, M., "Data Mining - Concepts and Techniques", 3rd Ed., Morgan Kaufmann Series, (Elsevier), 2008.
Alex Berson , S. J. Smith, "Data Warehousing, Data Mining & OLAP" , McGraw Hill
Tan, P.N., Steinbach, M. and Kumar, V., "Introduction to Data Mining", Addison Wesley Pearson, 2006
Pujari, A. K., "Data Mining Techniques", 4th Ed., Sangam Books.
Oded Maimon, Lior Rokach, The Data Mining and Knowledge Discovery Handbook, Springer, 2005.
S. Weiss and N. Indurkhya, Predictive Data-Mining: A Practical Guide, Morgan Kaufmann, 1998
S. Weiss, N. Indurkhya, T. Zhang and F. Damerau, Text Mining: Predictive Methods for Analyzing Unstructured Information, Springer, 2004.

IT479 Signals and Systems (3-0-2) 4

Signals in Physical World: Continuous Time Signals and Spectra, Fourier Series, Fourier Transforms; Signals in Digital World: Sampling, Quantization, Interpolation, Discrete Time Signals and Spectra, Discrete Fourier Transforms: Fast Fourier Transforms, Discrete Cosine Transforms, Continuous-time Systems: Continuous Linear Time Invariant, Linear Time Variant, Laplace Transforms; Discrete-time Systems: Linear Shift Invariant, Linear Shift Variant, Z-Transforms; Convolution and Correlation; Filters: Feed forward and Feedback; Modulation Techniques: AM, FM, PAM, PCM, Multiplexing Techniques: FDM and TDM; Compression: Text (Huffman Coding, Arithmetic Coding, LZW Coding, Run Length Coding); Audio (MP3); Image (JPEG); Video (MPEG4).

Michael Stiber and Bilin Stiber, "Signal Computing: Digital Signals in the Software Domain", Published by University of Washington Bothell, 2016.
A.V. Oppenheim, A.S. Willsky and S. Hamid Nawab, Signals and Systems, 2nd Edition, Pearson, 2015.
Rodger E. Ziemer, W.H. Tranter and D.R. Fannin, Signals and Systems, 4th Edition, Pearson, 2014.
B.P. Lathi and Roger Green, Linear Systems and Signals, 3rd Edition, Oxford University Press, 2017.
M.J. Roberts, Signals and Systems - Analysis Using Transform Methods & MATLAB, McGraw-Hill, 2017.
Luis F. Chaparro, Signals and Systems Using MATLAB, 2nd Edition, Academic Press, 2014.

IT480 Social Computing (3-0-2) 4

Emergence of the Social Web, Statistical Properties of Social Networks, Network analysis -concepts and graph centrality measures, Complete networks, Ego Networks, Random networks, Homophily, Small World Phenomenon, Structural Holes, Time, Sub-groups, Blockmodels and Strategic Network Formation, Empirical Models of Network Formation, Community detection, Influence maximization, Link mining and prediction, Social network based recommender systems, Anomaly detection in social networks, Mining Discussion networks, Visualizing Online Social Networks, Large-scale social network analysis applications and case studies, Emerging trends and issues.

Computational Social Network Analysis: Trends, Tools and Research Advances, Springer, 2012
Charu C. Aggarwal, —Social Network Data Analytics, Springer; 2014
Evolution in Social Networks. Ajith Abraham, Aboul Ella Hassanien, Václav Snášel
Borko Furht, —Handbook of Social Network Technologies and Applications, Springer, 1st edition, 2011
Giles, Mark Smith, John Yen, —Advances in Social Network Mining and Analysis, Springer, 2010.

IT481 Capstone project 4

Every department has to include the cornerstone, capstone project in the curriculum. It may be offered as an elective with 4 credits. For such projects, the student has to register in his/her department in the beginning of 3rd semester. The registration details of such students are to be maintained in the Department. The student to work on this project from 3rd semester to 7th semester. The student has to submit a report to the department at the end of every semester. Formally the registration for this course has to be done in the seventh semester and the student has

to submit a final report at the end of seventh semester. The assessment to be done at the end of seventh semester by a duly constituted committee at the department level, with the guide as a member. The student has to submit a final report at the end of seventh semester.