M.Tech in Information Technology

Suggested Plan of Study:

Sl. No.	Semester			
	I	II	III	IV
1	IT700	IT750	IT891/ IT897	IT899
2	IT701	IT751	IT898	
3	IT702	IT752		
4	Elective 1	Elective 3		
5	Elective 2	Elective 4		
6	----	IT890		

Credit Requirements

Category	Minimum Credits to be Earned
Program Core (Pc)	24
Elective Courses (Ele.)	14
Mandatory Learning Courses (MLC)	4
Major Project (MP)	10
Total	52

Programme Core Courses (Pc)

IT700	Advanced Algorithms	(3-0-2) 4
IT701	Advanced Database Systems	(3-0-2) 4
IT702	Deep Learning	(3-0-2) 4
IT750	Cyber Security	(3-0-2) 4
IT751	Distributed Computing Systems	(3-0-2) 4
IT752	Web and Social Computing	(3-0-2) 4

Elective Courses (Ele)

IT800	Mobile Computing	(3-0-0) 3
IT801	Genetic Algorithms	(3-0-2) 4
IT802	Artificial Intelligence	(3-0-0) 3
IT803	Software Architecture	(3-0-0) 3
IT804	Artificial Neural Networks	(3-0-2) 4
IT805	Topics in Web Semantics	(3-0-2) 4
IT806	Perceptual Audio and Speech Processing	(3-0-0) 3
IT807	Enterprise Resource Planning and Systems	(3-0-0) 3
IT808	Cyber Law and Intellectual Property Issues	(3-0-0) 3
IT809	Data Warehousing and Data Mining	(3-0-2) 4
IT810	E-Commerce	(3-0-0) 3
IT811	Web Services	(3-0-0) 3
IT812	Virtual Reality	(3-0-0) 3
IT813	Computer Vision	(3-0-2) 4
IT814	Cloud Computing	(3-0-2) 4
IT815	System Integration	(3-0-0) 3
IT816	Mobile Adhoc Networks	(3-0-2) 4
IT817	Wireless Sensor Networks	(3-0-2) 4
IT818	Intelligent Information Systems	(3-0-0) 3
IT819	Blind Signal and Image Processing	(3-0-0) 3
IT820	Information Technology for Healthcare	(3-0-0) 3
IT821	Perceptual Image and Video Processing	(3-0-0) 3
IT822	Advanced Computer Networks	(3-0-2) 4
IT823	Topics in Natural Language Processing	(3-0-2) 4
IT824	Topics in Soft Computing	(3-0-2) 4
IT825	Designing Internet of Things	(3-0-2) 4
IT826	Cyber-Physical Systems	(3-0-0) 3
IT827	High Performance Computing	(3-0-2) 4
IT828	Modern Cryptography	(3-0-2) 4
IT829	Advanced Computer Architecture	(3-0-0) 3
IT830	Multimedia Information Retrieval	(3-0-2) 4
IT831	Game Theory	(3-0-0) 3
IT832	Blockchain Technologies and Appliations -Decentralization and Smart Contracts	(3-0-2) 4
IT833	Advanced Time Series Analysis	(3-0-2) 4
IT834	Performance Evaluation of Computer Systems and Software	(3-0-2) 4
IT835	Advanced Data Analytics	(3-0-2) 4
IT836	Advanced Topics in 5G	(3-0-2) 4
IT837	Spatial Database and Applications	(3-0-2) 4
IT838	Quantum Cryptography	(3-0-2) 4

Mandatory Learning Courses (MLC)

IT890	Professional Practice / Seminar	2
IT891 / IT897	Practical Training / Minor Project (To be completed during Vacation between 2nd & 3rd Sem.)	2

Major Project (MP)

IT898	Major Project-I	4
IT899	Major Project-II	6

DEPARTMENT OF INFORMATION TECHNOLOGY

IT700 Advanced Algorithms **(3-0-2) 4**

Review of algorithm analysis. Stable Matching Problem, Algorithm design techniques: recursion, branch-and-bound, divide and conquer, greedy, dynamic programming; integer linear programming; polynomial and matrix multiplications: Fast Fourier Transforms (FFT), FFT Algorithms, Amortized analysis, Advanced Data Structures to implement Disjoint Sets, Priority Queues and other Dynamic Sets. Randomized algorithms to solve fundamental problems like sorting, MST, min-cuts, geometric problems, caching, load balancing, etc. Reductions and theory of NP-complete problems, Approximation algorithms, Local Search heuristics and On-line 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.

IT701 Advanced Database Systems **(3-0-2) 4**

Design of database kernels, Schema integration, Data warehousing, Distributed database design, Distributed query processing, Distributed transaction processing, Object-Relational databases, Emerging database technologies and applications, Application of conceptual and physical design to the real world database problems, Research Trends.

M. Tamer Özsu, Principles of Distributed Database Systems, Prentice Hall, 2011.
Ceri S and Pelagatti G, Distributed Databases: Principles and Systems, McGraw Hill, 2009.
T Connolly and C Begg, Database Systems: A Practical Approach to Design, Implementation and Management, Pearson, 2015.
R. Elmasri and S. B. Navathe, Fundamentals of Database Systems, Addison-Wesley, 3rd ed., 2011.
R. Ramakrishnan and J. Gehrke, Database Management Systems, McGraw-Hill, 3rd ed., 2014.
M. Stonebraker and J. Hellerstein, Readings in Database Systems, Morgan Kaufmann, 4th ed., 2005.
M. Stonebraker, Dorothy Moore, Object-Relational DBMSs, Morgan Kaufmann, 2nd ed., 1998.
J. Han, M. Kamber and J. Pei, Data Mining: Concepts and Techniques, 3rd ed., 2012.

IT702 Deep Learning **(3-0-2) 4**

Basics of Applied Math and Machine Learning: Linear Algebra for Machine Learning, Probability and Information Theory, Numerical Computation, Machine Learning Basics.

Deep Networks: Deep Feed Forward Networks, Regularization for Deep Learning, Optimization for Training Deep Models, Convolutional Neural Networks, Sequence Modeling - Recurrent and Recursive Nets. 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

IT750 Cyberse Curity **(3-0-2) 4**

Basics of Network Security: Cryptography, Terminology, Mathematics (One way functions, Discrete Log problem, Integer Factorization), Background (App developers, Hosters, Listers, payloads, Attack life cycle), Authentication and Authorization, Defensive and Secure Programming, Threat Modeling and changes to SDL; Intranet Security: SPAM, Virus and Worms, Social Engineering, Network Management, Vulnerable Applications, Uneducated Users vs Spies, Firewall and DMZ, Piracy; Penetration Testing: Ethics, Moral, Legal values and repercussion, Procedures, Tools, Metasploit and Exploit db; Internet Security: Server side security (Webserver, Database server, Appserver, Compromised user accounts), Client side security (Browser security, Malicious Webserver and Victim Webserver, Malware and terms), Ecommerce (Internet Banking, E-shopping, Mobile Banking – Transactions/Reporting, Trading), Identity Theft (Password Stealing - Phishing / Keyloggers / Malware / Tab nabbing/Social Engg, Tools, Best Practices), Privacy (Introduction, Rights, Legal Issues, Online Services, Facebook, Google, Social Web and Virtual Worlds), Cloud Security, Mobile Security (Challenges and Malware); Provable Security, Secure Multi-party Computation,Recent Trends.

"Information Assurance – Dependability and Security in Networked Systems", Yi Qian David Tipper, Prashant Krishnamurthy, James Joshi, (Morgan Kaufmann Series in Networking), 2008.
"Network Security Essentials", William Stallings, 4th Edition, Pearson Education, 2008.
"Internet and Intranet Security", Rolf Oppliger, 2nd Edition, Artech House, 2007.
"Computational Intelligence in Information Assurance and Security", Nadia Nedjah et al, Springer 2007.
"Security in Distributed and Networking Systems", Yang Xiao and Yi Pan, World Scientific Publishing, 2007.
"Network Security Private Commn. in a Public World", C. Kaufman, R. Perlman, M. Speciner, Prentice Hall, 2002.
"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.
"Secure Multiparty Computation and Secret Sharing An Information Theoretic Approach", Ronald Cramer, Ivan Damgard and Jesper Buus Nielsen, 1st Edition, Cambridge University Press, 2015.
"Cryptography and Network Security", Behrouz A Forouzan/Debdeep Mukhopadhyay, 3rd Ed., McGraw-Hill, 2015.

IT751 Distributed Computing Systems (3-0-2) 4

Basic concepts - Computer networks, Distributed systems models and architectures, Design goals, Fundamental issues and transparencies in DCS, Ordering of events, Ordering of messages and concerned protocols, Global state detection, Process synchronization, Process communications, Distributed deadlock handling, Distributed scheduling, Load balancing techniques

Mukesh Singhal and Niranjan G. Shivaratri, Advanced Concepts in Operating System, Tata McGraw Hill, 2014.
Ajay .D. Kshemkalyani, Mukesh Singhal, Distributed Computing, Cambridge University Press, 2008 A.S Tanenbaum and M.V. Steen, Distributed Systems – Principles and Paradigms, PHI, 2015.
Randy Chow, Distributed Operating Systems and Algorithms, Addison Wesley, 1997.
G.F. Coulouies et al., Distributed Systems: Concepts and Design, Addison Wesley, 5th Ed., 2012.

IT752 Web and Social Computing (3-0-2) 4

The Web as a graph: structure and coverage concepts, Web graph analysis; Link structure and link analysis algorithms; The problem of Web Search: Handling unstructured, semi-structured, structured data on the Web; Search Engines and search issues; Web as a Distributed computing platform: Service oriented Architecture and REST based web services (Resource Oriented Architecture); Micro-services; Social computing on the Web: The Social Web, Mining Social-network Graphs: graph centrality concepts, clustering, partitioning, community detection, overlapping community detection techniques; Applications of Large-scale Machine Learning to Social Media analysis, Current trends and research problems.

Christopher Manning et al., "Information Retrieval", Cambridge University Press, 2008.
Alonso, G et al., "Web Services - Concepts, Architectures and Applications", Springer, 2004.
Cioffi-Revilla, Claudio. Introduction to Computational Social Science, Springer, 2014.
Jennifer Golbeck, Analyzing the Social Web, Morgan Kaufmann, 2013.
Pascal Hitzler et al., "Foundations of Semantic Web Technologies", Chapman & Hall, 2009.

IT800 Mobile Computing (3-0-0) 3

Evolution of Wireless and Cellular Systems;Wireless Propagation: Encoding, Modulation, Multiplexing, and Error Handling Techniques; MAC Layer: Channel Allocation Techniques; Study of Mobile Communication Systems: Infrastructure, Registration and basic Call Establishment & Termination, Hand off, Roaming Support;Threat, Security & Privacy Issues; Ad-Hoc & Sensor Networks: Basic architecture/structure, terminology and Nomenclatures, Routing Protocols; IEEE802.11 & 802.15; Recent Trends: Ultra-Wideb and Technology, Sensor Networks, and Bluetooth;

Joschen Schiller,Mobile Communications, Pearson Education, 2003 Dharma Prakash Agarwal & Qing-AnZeng, Wireless & Mobile Systems,CENGAGE, 2nd Edition, 2006. William Stallings ,Wireless Communication & Networks, Prentice HallofIndia, 2nd Edition,2004.

IT801 Genetic Algorithms (3-0-2) 4

Robustness of traditional optimization and search techniques, Simple Genetic Algorithms, Similarity templates, goals of optimization, SchemaTheorem of John Holland, Computer Implementation of genetic algorithms; Applications of genetic algorithms, advanced operators and techniques in genetic algorithms; Recent research Trends. *David Goldberg,Genetic Algorithms in search ,optimizations and machine learning, Addition Wesley, 1999 Charles L Karr and L Michael Freeman, Industrial applications of Genetic Algorithms, CRC Press 1998.*

IT802 Artificial Intelligence (3-0-0) 3

Problem Solving: Solving Problems by Searching, heuristic search techniques, constraint satisfaction problems, stochasticse archmethods. Game Playing: minimax, alpha-beta pruning. Knowledge and Reasoning: Building a Knowledge Base: Propositional logic, first order logic, situation calculus.Theorem Proving in First Order Logic. Planning, partial order planning. Uncertain Knowledge and Reasoning, Probabilities, Bayesian Networks.Learning: Overview of different forms of learning,Learning DecisionTrees, Neural Networks. Introduction to Natural Language Processing, Applications and Research Trends.

Nilsson, Nils, ArtificialIntelligence:A NewSynthesis.MorganKaufmannPublishers,1998. Russell, StuartJ andNorvigPeter, ArtificialIntelligence:A ModernApproach,PrenticeHall,2003. NPTELVideos: ArtificialIntelligence

IT803 Software Architecture (3-0-0) 3

Definition and overview of software architecture, The architecture business cycle: what influences software architects, Different Architectural styles, Architecture description language, Understanding and achieving quality attributes, Attribute-driven design, Documenting software architecture, Evaluating software architecture, Architecturere use, Case studies and Recent Research Trends.

Mary Shaw, David Garlan,"Software Architecture", Prentice HallIndia,2000 Bass, Len; Paul Clements, Rick Kazman,. Software Architecture In Practice, Second Edition, Addison- Wesley,2003. Clements Pauletal, Documenting Software Architectures: Views and beyond, Addison-Wesley,2003.

IT804 Artificial Neural Networks (3-0-2) 4

Introduction to Artificial Neural Networks, Artificial Neuron Model and Linear Regression, Gradient Descent Algorithm, Nonlinear Activation Units and Learning Mechanisms, Associative Memory Model, Statistical Aspects of Learning, Single-Layer Perceptions, Least Mean Squares Algorithm, Perceptron Convergence Theorem,Bayes Classifier, Back Propagation Algorithm, Multi-Class Classification Using Multi-layered Perceptrons,Radial Basis Function Network, Principal Component Analysis, Independent Component Analysis, Self Organizing Maps, Applications and Research Trends.

Simon Haykin,"NeuralNetworks- A comprehensiv e foundations",Pearson,2004.

Laurene Fausett:"Fundamentals of Neural Networks:Architectures, Algorithms, and Applications",Prentice Hall.

J *A.Freeman, D M. Skapure:Neural Networks Algorithms, Applications & Programming Techniques, Addison-Wesley. James A. Anderson,"An Introduction to Neural Networks",Prentice Hal lof India. Yegnanarayana:"Artificial Neural Networks",Prentice Hall of India,2004.*

IT805 Topics in Web Semantics (3-0-2) 4

Semantics vs. Syntax, Structure, Formal Languages, Semantic Web Architecture, Vocabularies (Dublin Core, RSS, FOAF); Taxonomies – Descriptive Taxonomies, Navigational Taxonomies, Data Management Vocabulary, Roles of taxonomy in Content Management, Building and Maintaining taxonomies; Structured Web Documents and Resource Description Framework – metadata standards, RDF and metadata processing; Knowledge Organization Systems; Classification of organization systems; Relationship Models; Programming with RDF/XML; Web Ontology Language (OWL) - Ontology, Domain Modeling - Logic, Inferencing, Context; Programming with Ontology; Logic Reasoning for the Semantic Web - Classification and semantic metadata extraction using statistical, statistical learning/AI, lexical and natural language, knowledge based techniques; Linked Data, Role of Agents, Semantic Web and Intelligent Agents; Semantic Applications, Review of some of active projects and W3C initiatives, Contributions of IR, AI, Logic, and NLP to Semantic Web and Research Trends.

Pascal Hitzler et al, Foundations of Semantic Web Technologies, Chapman & Hall, 2009. Karin Breitman et al, Semantic Web: Concepts, Technologies and Applications, Springer, 2010. Grigoris Antoniou and Frank van Harmelen, A Semantic Web Primer, The MIT Press, 2nd Edition, 2008. John Hebeler, Matthew Fisher, Ryan Blace, Andrew Perez-Lopez, Semantic Web Programming, Wiley, 2009. Semantic Web – W3C https://www.w3.org/standards/semanticweb/

IT806 Perceptual Audio and Speech Processing (3-0-0) 3

Fundamentals of Audio and Speech Processing; Speech and Audio Analysis: Transforms–STFT, DCT, Waveletsand Gammatone Filterbanks; Audio and Speech Compression Standards:MPEG, AC-3, EAC-3 and AAC; Human Auditory Perception; Perceptual Audio Quality Metrics, Perceptual Audio Coding and Processing of Digital Speech; Speech and Audio Storage, Retrieval and Communication; Applications and Research Trends.

Jacob Benesty, M.Mohan Sondhi and Yiteng Huang, Handbook of Speech Processing, Springer-Verlag,2008.

Andreas Spanias et al.,"Audio Signal Processing and Coding",Wiley-Interscience,2007.

Soren Bech and Nick Zacharov,"Perceptual Audio Evaluation- Theory,Method and Application",Wiley,2006.
HugoFastland Eberhard Zwicker,"Psychoacoustics:FactsandModels",Springer,3rd edition,2006.
Marina Bosiand Richard E.Goldberg,"Introduction to Digital Audio Coding Standards",Springer,2002.
BenG.and Nelson M.,"Speech and Audio Signal Processing: Perception of Speech and Music", Wiley,1999.

IT807 Enterprise Resource Planning and Systems **(3-0-0) 3**

Enterprise Resource Planning and Systems (ERP) – Introduction, ERP & Related Technologies, Customer Relationship Management (CRM), Human Resource Management (HRM), ERP Implementation Life Cycles, ERP Case Studies.

Alexis Leon-Enterprise Resource Planning.
V.K.Garg & N.K.Venkitakrishnan, ERPWare:ERP Implementation Framework.
Garg&Venkitakrishnan,ERP:ByLeon,ERP-ConceptsandPlanning.
VinodKumarG&N.K.Venkitakrishna,ERP - ConceptsandPractice,PHI,1998
SunilC&Peter-SCM-StrategyandPlanningandoperation,PearsonEducation,LPE,2002

IT808 Cyber Law and Intellectual Property Issues **(3-0-0) 3**

The Right to Access, Anonymity, Data Protection, Malicious Code, Spam, Cyber-Hooliganism, Cyber-Stalking, Identity Theft, Cyber-Terrorism, Cyber-War, Distance Contracting, Obscene Publications, Digital Signatures, Civil Liberties, Civil Liability, Civil Remedies,Criminal Liability,Criminal Penalties,Sovereignty and Jurisdiction; Controlling Digital Goods: Copyright, Protection of Online Commercial Identity (TradeMark, DomainName), Controlling Online Business Methods: Patent, ICANN Dispute Resolution Policy and WIPO, Legal Positionon Database protection in U.S, E.U and India,Protection of Multimedia works in cyber space,Copyright In fringement & Liability of Network Service provider.

AhmedKamal, TheLawofCyberSpace,United Nations Institute of Training and Research, October2005
Intellectualpropertyissuesinsoftwarepublishedby NationalAcademyPress,Washington D C1991
Hahn,Robert W.,IntellectualPropertyRightsinFrontierIndustries:SoftwareandBiotechnology,AEIPress,2005.

IT809 DataWarehouing and Data Mining **(3-0-2 4**

Data warehousing

Data Warehouse Definition and Architecture, Data Cube, Multi-Dimensional View of Data and the OLAP Operations, RDBMS, Display the Cuboid using RDBMS Table, Materialized View/ View Materialization, OLAP Server: (ROLAP, MOLAP, HOLAP), Views Materialization: Linear Cost Model, Data Warehouse Database Design (Fact and Dimension Tables, 4 Stage Design Process, Star Schema, Snowflake Schema, Fact Constellation Schema), Retail Sales Business Process (Date, Product, Sales Dimensions, Promotion Dimension, Degenerate Dimension, Factless Fact Table), Inventory Business Process, Slowly Changing Dimensions (Type 1, Type 2, Type 3, Hybrid), Rapidly Changing Dimensions, Indexing

Data Mining

KDD and Data Mining, SQL and Data Mining, Data Preprocessing (Missing Data Handling, Noisy Data Handling, Discretization and normalization), Association Rule Mining, A-priori Algorithm, Dynamic Itemset Counting Algorithm, Mining Frequent Patterns: Mining FP Trees, Sequential Pattern Mining, Clustering, K-means Clustering, K-mediod Clustering, PAM CLARA, CLARANS, Agglomerative Hierarchical Clustering Algorithm, CF Vector, CF Tree, BIRCH, Classification: Quantifying Classifier Performance, MLP as Classifier, Back Propagation Algorithm, Decision Trees and its Construction Algorithms, Problems on Decision Tree, MLP, Overview on Temporal and Spatial Data Mining, Brief Introduction to the other Mining Techniques: Sequence Mining, Text Mining, Web Mining

J. Hahn and Micheline Kamber - Data Mining: Concepts and Techniques (Morgan Kaufmann)
R.Kimball - DataWarehouse Toolkit (J.Wiley)
A.K.Pujari - Data mining (University Press)
OdedMaimon, LiorRokach, The Data Mining and Knowledge Discovery Handbook, Springer,2005
G.Piatetsky–Shapiroand W.J.Frawley (Editors),Knowledge Discovery in Databases,AAAI/MITPress,1991
Sushmita Mitra and Tinku Acharya,Data Mining,Wiley-Interscience,2004.

IT810 E-Commerce **(3- 0-0) 3**

Infrastructure and Tools for E-Commerce, Current Trends in E-Commerce applications development,The Business of Internet Commerce,Enterprise level E-Commerce, Security and encryption, Electronic payment systems,Search engines, Intelligent agents in E-Commerce, On-lineauctions, Data mining for e-commerce, Webmetrics,

Recommender systems, Knowledge management, Mobilee-commerce, Legal, ethical & social issues and recenttrends.

Henry Chanetal.,E-Commerce-Fundamental and applications,John Wiley & Sons,2002
G.Winfield Treese and Lawrence C.S,Designing Systems for Internet Commerce,Pearson Education, LPE,2002
Fensel, Dieter, Brodie M.L.,Ontologies:A Silver Bullet for Knowledge Management & E-Commerce, Allied Publishers,2004.
Zimmermann, Olaf;Tomlinson, MarkR.;Peuser,Stefan, Perspectives on Web Services, Allied Publishers,2004.

IT811 Web Services **(3-0-0) 3**

Basic concepts, Enabling Infrastructure, Core functionality and standards, Service semantics, Web service composition,Servicedevelopment,applicationsandresearchtrends.

Alonso,G etal,WebServices-Concepts,ArchitecturesandApplicationsSeries:Data-CentricSystemsand Applications2004.
SanjivaWeerawaranaetal,WebServicesPlatformArchitecture:SOAP,WSDL,WS-Policy,WS-Addressing,WS-BPEL,WS-ReliableMessaging,andMore,PrenticeHall,2005.
ThomasErl,Service-OrientedArchitecture:Concepts,Technology,andDesign,PrenticeHall,2005.
J2EEWebServices,RichardMonson-Haefel,Pearson(LPE),2005.

IT812 Virtual Reality **(3-0-0) 3**

Introduction toVirtualReality Technology and its effectiveness in Real-Time Applications, Scientific Visualization, Input Devices: Trackers, Navigation and Gesture Interfaces; Output Devices: Graphics, 3D Sound and Haptic Displays; Computing Architectures for Virtual Reality, Modeling, Virtual Reality Programming, Human Factors in Virtual Reality; Virtual Humans: Overview of Virtual Humans, Face Cloning & Face Motion Capture/Analysis, Body Cloning & Body Motion Capture, Body Gesture Recognition and Action Response, Cloth Simulation and Research Trends.

Gerard Jounghyun Kim, Designing Virtual Reality Systems–The Structured Approach, Springer-Verlag,2005. NMagnenat-
Thalmannand D Thalmann, Handbook of Virtual Humans,Wiley,2004.
L J. Hettinger, M W.Haas,Virtual & Adaptive Environment:Apps /Human Performance,Lawrence Erlbaum,2003.
GrigoreCBurdea and Phillippe Coiffet, Virtual Reality Technology, John Wiley,2003.

IT813 Computer Vision **(3-0-2) 4**

Introduction to Computer Vision, Color + Math basics, Linear Algebra, Pixels and filters, Edge detection, Features and fitting, Feature descriptors, Resizing, Semantic segmentation, Clustering, Object recognition, Dimensionality reduction, Face identification, Visual Bag of Words, Detecting objects by parts, Image classification, Motion Tracking, Introduction to Deep Learning.

Sonka M., Hlavac V., Boyle R., Image Processing Analysis and Machine Design. PWS Publishers Ballard D., Brown C., Computer Vision, Prentice Hall, 1982.
R. C. Gonzalez and R. E. Woods, Digital Image Processing, Addison Wesley, 1992.
Digital Image Processing and Computer Vision";; John Wiley and Sons, 1989.
Robert J. Schallkoff , Pattern Recognition: Statistical. Structural & Neural Approaches, John Wiley and Sons, 1992.
D. A. Forsyth and J. Ponce, Computer Vision: A Modern Approach, Pearson Education, 2003.
Richard Szeliski, Computer Vision: Algorithms and Applications, Springer-Verlag, 2011.

IT814 Cloud Computing **(3-0-2) 4**

Introduction to Cloud Computing, Cloud Computing Delivery Models, Open Source and Industry case Studies of Cloud (ApacheVCL, Amazon, IBM and Eucalyptus) Introduction to Map/Reduce and Apache Hadoop Programming models for cloud computing, examples/applications, Virtualizations as an enabler for cloud computing infrastructure, Cloud Application Design & Development, Containers and Dockers.

GeorgeReese,CloudApplicationArchitectures,O'ReillyPublications,2009 Tim Mather,Subra Kumaraswamy, Cloud Security and Privacy,O'Reilly,2009 Tom White,The Hadoop–Definitive Guide,O'Reilly,2009.
Arshadeep Bagha and Vijay Madisetti, Cloud Computing: A Hands on Approach, Universities Press, 2014.

IT815 System Integration **(3-0-0) 3**

Enterprise Integration Drivers, Requirements and Strategies: The Business Imperative for Enterprise Integration, Business Drivers and Requirements, Enterprise Integration Strategy; Enterprise Integration Architecture: Overview,

Current Integration Architecture Assessment, Technical Integration Architecture, Service Integration Architecture, Information Integration Architecture, Process Integration Architecture; Enterprise Integration Solutions: Application Integration, Information Integration, Composite Application Integration, Process-Driven Integration, Best Practices for Enterprise Integration; Currenttrends.

B.G-Bernstein, W.Ruh. Enterprise Integration: Essential Guideto Integration Solutions, Addison-Wesley, 2005.
C.Britton, P.Bye, ITArch &Middleware: Strategies for Building Large Integrated Systems, Addison-Wesley,2004

IT816 Mobile Adhoc Networks (3-0-2) 4

Mobile adhoc networking; imperatives, challenges and characteristics, Bluetooth networks, Routing approaches, Proactive and reactive protocols. Clustering and hierarchical routing, Multipath routing, Security aware routing, Energy efficient communication in adhoc networks, Measuring energy consumption, Power save protocols, Maximum life time routing, Secure routing protocols, Intrusion detection, Security considerations in adhoc sensor networks, Key management, Characterization of IP traffic, QOS classification, Self similar processes, Statistical analysis of non–real time traffic and real–time services and Recenttrends.

C.S.Murthy & B.S.Manoj, AdHoc Wireless Networks, Pearson, 2006.
T.Janevski, Traffic Analysis and Design of Wireless IP Networks, Artech House, 2003.
Ozan K.Tonguz & Gianluigi, Adhoc Wireless Networks,Wiley, 2006.

IT817 Wireless Sensor Networks (3-0-2) 4

Introduction to wireless communication networks and wireless sensor networks, Network architecture and design principles, MAC and Link-layer protocols, Topology controlin WSN, Routing protocols, information aggregation, information storage and query, localization, Security issues, Recenttrends: multimedia sensor networks etc.

F. *Zhaoand L. Guibas, Wireless Sensor Networks, Elsevier/Morgan- Kaufmann,2004 William Stallings, Wireless Communications and Networks, PrenticeHall,2004. P.Nicopolitidis,M.S.Obaidat, G.I.Papadimitria, A.S.Pomportsis, Wireless Networks,John Wiley & Sons,2003. K.Pahlavan, P.Krishnamoorthy, Principles of Wireless Networks,- A united approach-Pearson Education,2002.*

IT818 Intelligent Information Systems (3-0-0) 3

Emerging Technologies and applications with latest knowledge applied to customized logic systems, agent based Approaches to modeling, and human-based models, multi-mobile agent systems, the product development process, fuzzy logic systems and ambient intelligent environment such as development of information and communication technologies, multimedia data hiding and watermarking algorithms for real world audio and video applications.

XuanF.Zha, Artificial Intelligence and Integrated Intelligent InfoSystems: EmergingTech. & Apps,IGI Global, 2006 Jialie Shen, Intelligent Music Information Systems: Tools and Methodologies, Idea Group Publishers, 2007 Pan, J.-S; Huang, H.-C; Jain, L.C.;Fang,W.-C; Intelligent Multimedia Data Hiding, Springer,2007.

IT819 Blind Signal and Image Processing (3-0-0) 3

Introduction to Blind Signaland Image Processing: Principal Component analysis (PCA), Blind Source Separation (BSS) and Independent Component Analysis(ICA), BSS of Instantaneous and Convolutive Mixtures, Sequential Blind Signal Extraction, Robust BSS/ICA with noisy data; Learning Algorithms for Estimation of Sources; Applications: Audio, Speech, Image and Biomedical Signals; Research Trends.

A.*Cichocki,S.Amari, Adaptive Blind Signal and Image Processing:Learning Algorithms & Apps, John Wiley,2002.*
Hyvarinen, J. Karhunen, E.Oja, Independent Component Analysis, John Wiley, 2001
C S.Roberts, R. Everson, Independent Components Analysis: Principles & Practice, Cambridge Univ. Press,2001.
A.S. Bregman, Auditory Scene Analysis",MIT Press, 2nd Edition,1999 Handbookon Speech Processing and Speech Communication, Springer, 2007.

IT820 Information Technology for Health Care (3 -0-0) 3

Evolution of IT Enhanced Healthcare, Internet Technologies in Telemedical Systems, Wireless Systems in E-Health, Decision Support Systems in Medicine, Health Telematics Networks, Computer Aided Diagnosis and Recent Trends.

Krzysztof Zielinski, Mariusz Duplaga and David Ingram, IT Solutions For Healthcare, Springer,2006
Robert E Hoyt, Nora Bailey, Ann Yoshihashi, *Health Informatics, 5thEdition, Lulu Publishers, 2012 Kevin Beaver, Healthcare Information Systems, Auerbach Publications, 2nd Edition, 2002.*

IT821 Perceptual Image and Video Processing (3-0-0) 3

Fundamentals of Image and Video Processing; Image and Video Analysis: Image Transforms-DCT, Hadamard,

Haar, K L and Wavelets; Image and Video Compression Standards: JPEG, JPEG2000, MPEG1, MPEG2, MPEG4 & MPEG7, H.264 and AVC; 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 and Communication; Applications Image and Video Processing and Research Trends.

Perceptual Based Image Processing, Morgan & Claypool,2009
Al Bovik,"Hand book of Image and Video Processing",Elsevier Academic Press,2005
H.R.Wuand K.R.Rao,"Digital Video Image Quality and Perceptual Coding",C R C Press,2005
R. C.Gonzalez and R E Woods,"Digital Image Processing",Pearson Education,2002

IT822 Advanced Computer Networks **(3-0-2) 4**

Overview of computer networks, seven-layer architecture,TCP/IP suite of protocols etc.MAC protocols for high-Speed LANS, MANs, and wireless LANs. (For example, FDDI, DQDB, HIPPI, Gigabit Ethernet, Wireless Ethernet, etc.) Fast access technologies. (Forexample, ADSL, Cable Modem, etc.) IPv6:WhyIPv6, basic protocol, extensions and options, support for QoS, security, etc., neighbor discovery, auto-configuration, routing. Changes to other protocols. Application Programming Interface for IPv6. Mobility in networks. Mobile IP. IP Multicasting. Multicast routing protocols, address assignments, session discovery, etc. TCP extensions for high-speed networks, transaction-oriented applications.OthernewoptionsinTCP.

W.R.Stevens,TCP/IPIllustrated,Volume1:TheProtocols,AddisonWesley,1994.
G.R.Wright,TCP/IPIllustrated,Volume2:TheImplementation,Addison Wesley,1995.
W.R.Stevens, TCP/IPIllustrated,Volume3:TCPforTransactions,HTTP,NNTP,andtheUnixDomainProtocols, AddisonWesley,1996.
R.Handel,M. N.Huber,S. Schroeder,ATMNetworks:Concepts,Protocols,Applications,AddisonWesley,1998.
C.E.Perkins,B.Woolf,andS. R.Alpert.MobileIP:DesignPrinciplesandPractices,AddisonWesley,1997.

IT823 Topics in Natural Language Processing **(3-0-2) 4**

Introduction to Language Modeling, History and Applications, Text Processing Systems and architectures, N-grams, Lexical semantics and word-sense disambiguation, part of speech tagging, spelling correction, Text Classification – basics and process, tools, learning algorithms, Probabilistic Similarity Measures and Clustering, Sentiment Analysis, Generating and developing sentiment lexicons, learning lexicons, Information Retrieval models, Information Extraction - Maximum Entropy models, Relation Extraction, Stochastic Tagging, and Log-Linear Models, Semantics in NLP - Question Answering Models, passphrase analysis and answer generation, Summarization, 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
C.D. Manning and Hinrich Schütze, "Foundations of Statistical Natural Language Processing" MIT Press, 1999
Steven Bird. "Natural Language Processing with Python". O'Reilly, 2009
James Allen, "Natural Language Understanding". Benjamin/Cummings, 2Ed., 1995

IT824 Topics in 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

Vojislav Kecman, Learning and Soft Computing , Pearson Education (Asia) PTE, 2004 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 et al., Handbook of Research on Soft Computing and Nature-Inspired Algorithms, IGI Global, 2017.
Evolutionary Algorithms for Solving Multi-Objective, Optimization Problems, 2nd Edition, Collelo, Lament, Veldhnizer, Springer

J. Han and M. Kambar, Data Mining: Concepts and Techniques, Morgan Kaufmann, 2008.

IT825 Designing Internet of Things **(3-0-2) 4**

Introduction to Internet of Things: Technology drivers, Business drivers, Applications of IoT. Sensors and sensor nodes: sensing devices, sensors modules, nodes and systems. Connectivity and networks: Wireless Technologies for IoT, Edge connectivity and protocols, Wireless Sensor Networks.Communication technology for IoT, Design Principles for Connected Devices, Internet principles, Prototyping embedded devices, Prototyping the physical design, Prototyping Online Components, Business models. Design of Semantic IoT, Cloud analytics and applications.

Olivier Hersent, David Boswarthick, Omar Elloumi, The Internet of Things: Key applications And protocols,Wiley publications2015
Adrian McEwen And Hakim Cassimally, Designing Internet of Things, John Wiley and Sons2014
Karin Breitman, Marco Antonio Casanovaand Walter Truszkowski, Semantic Web: Concepts, Technologies, and Applications, Springer2007
Charles Bell, Beginning Sensor Networks with Arduino and Raspberry Pi, Apress, 2013
Zhong,N.,Ma,J.,Liu, J., Huang,R., Tao,X.Wisdom Web of Things, Web Information Systems Engineering and Internet Technologies Book Series, 2016 Rajkumar Buyya Amir Vahid Dastjerdi, Internet of Things- Principles and Paradigms, Morgan Kaufmann, 2016 Kai Hwang, Jack Dongarra, Geoffrey C Fox,Distributed and Cloud Computing: From Parallel Processing to the Internet of Thing, Morgan Kaufmann, 2012

IT826 Cyber Physical Systems **(3-0-0) 3**

Cyber physical system(CPS) Introduction, Industry standards, applications of CPS, CPS components : hardware platform, CPS networks, Software stack, scheduling real time control stacks. Principles of Automated Control Design: dynamical systems and stability, controller design techniques, stability analysis, performance under packet drop and noise. CPS implementation, Safety assurance of Cyber-Physical systems, Secure deployment of CPS, Mobile Cyber physical systems.

Andr´e Platzer. Logical Foundations of Cyber-Physical Systems. Springer, 2018
Raj Rajkumar, Dionisio de Niz, Mark Klein, Cyber- Physical Systems, Pearson Education, 2017 Rajeev Alur, Principles of Cyber-Physical Systems, MIT Press, 2015.

IT827 High Performance Computing **(3-0-2) 4**

High performance computing architectures, Fundamentals of Superscalar processors, Vector processors and Accelerators architecture – GPGPU, Xeon-Phis and FPGAs. Programming for HPC clusters – OpenMP and MPI programming. Programming for accelerators – OpenCL/CUDA/Xeon-PHIs. Domains for HPC (Microbiology, Engineering, Physics, Chemistry). HPC Benchmarks – LINPACK/HPL. Recent, relevant high-performance computing advances from literature from Supercomputing and other sources. Programming projects in the area of open source HPC applications. Introduction to Deep Learning frameworks like Caffe, Tensorflow. Implementation of HPC techniques in DNN frameworks incl. TPUs.

Dennis Abts, John Kim, High Performance Datacenter Networks - Architectures, Algorithms, and Opportunities. Mark Hill/Margaret Martonosi (Eds.). Synthesis Lectures on Computer Architecture,Morgan and Claypool, 2011.
David B. Kirk, Wen -mei W. Hwu, Programming Massively Parallel Processors: A Hands-on Approach (Applications of GPU Computing Series) Elsevier-2014
David j. Kuck, "High Performance Computing", Oxford Univ Press, 1996 Gary W. Sabot, "High Performance Computing", Addison-Wesley, 1995
John L Hennessy, David A Patterson, Computer Architecture - A Quantitative Approach, 5th Edition, Morgan Kaufmann, 2011.

IT828 Modern Cryptography **(3-0-2) 4**

Symmetric Key Cryptography: The notion of a symmetric key cryptography, Data Encryption Standard (DES), Double DES, Triple DES and cryptanalysis. Advanced Encryption Standard (AES). Public Key Cryptosystems: Fundamentals of Public-key Cryptography, RSA public key cryptosystem, ElGamal public key cryptosystem and Elliptic Curve Cryptosystems. Integer Factorization Problem: Trial division, Pollard' s rho factoring algorithm, Pollard's p-1 factoring algorithm, Elliptic Curve Factoring, Random Square Factoring methods, Quadratic sieve Factoring, Number Field Sieve Factoring. Digital Signatures: RSA based signature scheme, ElGamal based signature scheme, Schnorr signature scheme, Digital Signature Algorithm (DSA). Key Distribution and Key Agreement Protocols: Key Pre-distribution, Diffie-Hellman key Exchange. Authentication: simple authentication protocol and

possible attacks, Strong password protocols, Key Distribution Centers based authentication protocols.
"Cryptography and Network Security: Principles and Practices", 4th Edition, W. Stallings, Prentice Hall, 2005.
"Cryptography and Network Security", 6th Edition, William Stallings, pearson, 2013.
"Applied Cryptography", 2nd Edition, Bruce Schneier, Wiley, 1996.
"Handbook of Applied Cryptography", A. Menezes, P. Van Oorschot, S. Vanstone, CRC Press, 5th Printing, 2001.
"Understanding Cryptography A Textbook for Students and Practitioners", Christ of Paar, Jan Pelzl, Springer.
"Cryptography, Theory and Practice", 3rd Edition, Douglas R. Stinson, CRC Press, 2006.
"Network Security Private Communication in a Public World", C. Kaufman et al., Prentice Hall, 2002.
"Cryptography & Network Security", Behrouz A Forouzan & Debdeep Mukhopadhyay, 3rd Ed., McGraw-Hill, 2015.

IT829 Advanced Computer Architecture (3-0-0) 3
Flynn's Classification, RISC Vs CISC, Data and control flow, Pipelining: Linear and non linear, pipeline hazards, instruction scheduling, Branch handling techniques, Dynamic Branch prediction, Arithmetic pipeline, VLIW architecture, Superscalar processors: Architecture, shelving, score boarding, Multiple issue and speculation, Limits of Instruction level parallelism. Software pipelining and global scheduling. Hardware assisted software ILP and IA64/Itanium case study. Instruction level Data-Parallel architectures: SIMD architectures, Systolic and Vector architecture; MIMD architectures, Systems interconnect architecture: Network properties/routing, Static/dynamic interconnection networks. Multiprocessor architectures, models of memory consistency, cache coherence/directory protocols. Multicore architecture. Performance evaluation. Design of simple computer architecture.
J. Hennesy and D. Patterson, Computer Architecture –A Quantitative Approach, 6th Ed., Morgan Kaufmann, 2017
Yan Solihin, Fundamentals of Parallel Multicore Architecture, Chapman and Hall/CRC Press, 2015
Dezso Sima, Peter Karsuk, Advanced Computer Architectures: A Design Space Approach, Addison- Wesley, 2002

IT830 Multimedia Information Retrieval (3-0-2) 4
Introduction to multimedia information retrieval, Characteristics of MM data; similarity-based retrieval model-retrieval framework; Benchmarking of multimedia information systems; Color- based Retrieval: color models; histogram model; indexing and retrieval; relevance feedback; histogram refinement; color cluster technique; Texture-based Retrieval: texture models; statistical models; combined color-texture representation; Shape-based Retrieval: shape matching; contour-based method (Fourier descriptors); region-based method (moment invariants); Audio Retrieval: characteristics of audio data; spectrum analysis; pitch tracking; techniques for audio feature extraction, similarity matching and retrieval; Video Retrieval: key-frame extraction; video retrieval techniques; Multimedia applications; Research Problems.
R. Jain, R. Kasturi, B.G. Schunck (1995), Machine Vision, McGraw-Hill.
B. Furht, S.W. Smoliar, H.J. Zhang (1995), Video and Image Processing in Multimedia Systems, Kluwer, Boston.
Roberto Raieli, "Multimedia Information Retrieval- Theory and Techniques", Elsevier, 1st Edition, 2013 Mark T Maybury, "Intelligent Multimedia Information Retrieval", AAAI Press, *MIT Press*
C. D. Manning, P. Raghavan and H. Schütze, Introduction to Information Retrieval, Cambridge Univ. Press, 2008.
Baeza-Yates & Ribeiro-Neto, Modern Information Retrieval, Pearson Education, 2010

IT831 Game Theory (3-0-0) 3
Introduction to Game Theory, Strategic Games and Nash Equilibrium, Illustrations of Nash Equilibrium, Mixed Strategy Nash Equilibrium, Extensive Games and Nash Equilibrium, Illustrations of Extensive Games and Nash Equilibrium, Evolutionary and Correlated Equilibrium - Evolutionary Game Theory.
Osborne, M.J, An Introduction to Game Theory, Oxford University Press, International Edition, 2009.
Mas-Colell, A., M.D. Whinston and J.R. Green Microeconomic Theory, Oxford University Press, 2012.
Roger B. Myerson, Game Theory: Analysis of Conflict, 1st Paperback Edition, Harvard University Press, 1997.
Gibbons, R, A Primer in Game Theory, Pearson Education, 1992.

IT832 Blockchain Technologies and Applications – Decentralization and Smart Contracts (3-0-0) 3
Theories of Cryptocurrency, Block chain and Distribution Systems. Understanding the emerging abstract models doe Block chain and Bitcoin Security, Application of block Chain, Byzantine fault tolerance, Security of Blockchain and decentralized schemes, attacks on Block Chain systems, Light weight protocols and algorithms based on block chain, block Chain Based IoT solutions, Block chain in crowdsourcing and crowdsensing, Block chain in Cyber Physical Systems, Block chain in Social Networking, block chain in 5G, Block Chain in edge and Cloud Computing, Block chain and Trust managements, Business Model destruction/creation caused by Block chain, Business value of blockchain.

Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, and Steven Goldfeder. Bitcoin and cryptocurrency technologies: a comprehensive introduction. Priceton University Press 2016.
Dac-Nhuong Le, Gulshan. Cryptocurrencies and Block Cahin and Applications, Decentralization and Smart Contracts, Wiley Publications.
Joseph Bonneau et al, SoK: Research perspectives and challenges for Bitcoin and cryptocurrency, IEEE Symposium on security and Privacy, 2015 (article available for free download) {curtain raiser kind of generic article, written by seasoned experts and pioneers}.
J.A. Garay et al, The bitcoin backbone protocol – analysis and applications EUROCRYT 2015 LNCS VOL 9057, (VOLII), pp 281-310. Serious beginning of discussions related to formal models for bitcoin protocols.
R. Pass et al, Analysis of Blockchain protocol in Asynchronous networks, EUROCRYPT 2017, A significant progress and consolidation of several principles.
R. Pass et al, Fruitchain, a fair blockchain, PODC 2017.

IT833 Advanced 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.

IT834 Performance Evaluation of Computer Systems and Software **(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 Theroy: open networks, closed networks , time-reversibility, RenewalReward, M/M/l, M/M/k, M/M/k/k, burke's theorem, Jackson networks, classed networks, load-dependent servers, BCMP result and proof, M/G/l full analysis, M/G/k, G/G/l, transform analysis (Laplace and z-transforms);
Simulation: 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, Matrix analytic methods;
Management of Server Farms: capacity provisioning, dynamic power management, routing policies;
Analysis of Scheduling: FCFS, non-preemtive priorities, preemtive 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.
A.Papoulis and S.U. Pillai, Probability, Random Variables, and Stochastic Processes, McGraw-hill.
A.Leon-Garcia, Probability and Random Processes for Electrical Enginering, Prentice Hall.
Michael Pinedo, Scheduling Theory, Algorithms and Systems, Prentice Hall.

IT835: Advanced Data Analytics **(3-0-2) 4**

Data science fundamentals, Nature of Data and its characteristics, Total information awareness, Bonferroni's Principle, Rhine's paradox, Mathematical fundamentals, Statistical descriptions of data, Inferential Analyis, Data preprocessing: Dealing with missing data – single and multiple data imputation, Entropy based techniques, Monte Carlo and MCMC simulations – Metropolis, M-Hastings algorithms, Gibbs sampling; Correcting inconsistent data, Deduplication, Entity resolution, Pairwise Matching; Regression-based modeling, Correlation and Covariance analysis, Aggregation, Sampling, Dimensionality Reduction; Feature extraction and feature selection; Streaming data analysis - Stream processing and online analytics, Dealing with infinite length, concept drift, concept/feature evolution, Visual analytics, Current trends and ongoing research.

Sinan Ozdemir, "Principles of Data Science - Second Edition" Packt Publishing, 2018

Sam Lau, Joey Gonzalez, and Deb Nolan, "Principles and Techniques of Data Science" 2019
Saltz and Stanton, "An Introduction to Data Science", Sage Publications, 2017
Jure Leskovec, Anand Rajaraman and Jeffrey Ullman, "Mining of Massive Datasets" Cambridge University Press
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

IT836: Advanced Topics in 5G **(3-0-2) 4**

The 5G architecture, Basics about RAN architecture, Integration of LTE and new air interface to fulfill 5G requirements, 5G deployments, Machine Type Communication (MTC) Introduction, MTC requirements, Fundamental techniques for MTC, Design principles, MTC Research Challenges, Proximity Services - Device-to-device (D2D) communications, D2D from 4G to 5G, D2D standardization, D2D in 5G: research challenges, Resource and Interference Management, Millimeter wave communications, Spectrum and regulations , Beamforming architecture, Dual connectivity, Beamforming techniques and the Research Challenges, Beam finding , Massive multiple-input multiple-output (MIMO) systems Introduction, MIMO in LTE, Single user MIMO, Multi-user MIMO, Research Challenges in MIMO, Handover in 5G, Handover Challenges, 5G and IoT Research Challenges, 5G and IoT use cases Driver Less Cars/busses and Smart City Applications, Smart Campus, Smart Building, Smart Classrooms, 5G Simulation - Implementation of 5G in Network Simulator - 3 (NS-3), D2D and mmWave patch installation, programs on resource allocation in D2D Communication, Handover in mmWave.

Afif Osseiran, Jose F Monserrat, Patrick Marsch, "5G Mobile and Wireless Communication Technology" Cambridge University Press, 2016
Erik Dahlman, Stefan Parkvall, Johan Sko ̈ld "5G NR: The Next Generation Wireless Access Technology", Elsevier, Academic Press, 2018
IEEE and ACM Transactions articles on 5G.

IT837: Spatial Database and Applications **(3-0-2) 4**

Introduction to Spatial Database, Applications domains of Spatial Dat Science, Common Spatial Data Types and Analysis, Conceptual Data Models for Spatial Databases, Logical Data Models for Spatial Databases (Raster Model and Vector Model), Physical Data Models for Spatial Databases (Clustering Methods (Space Filling Curves), Storage Methods (R-Tree, Grid Files), Concurrency Control (R-Link Trees), Compression Methods for Raster and Vector Data), Spatial Query Languages, Query Processing and Optimization (Strategies for Range Query, Nearest Neighbor Query, Spatial Joins (Tree Matching), Cost Models for New Strategies, Impact on Rule-based Optimization), Spatial Networks (Conceptual, Logical, and Physical Data Models, Query Languages, Graph Algorithms, Access Methods), Introduction to Spatial Data Mining (Auto-correlation, Co-location, Spatial Outliers, Classification (SAR, MRF)), Spatio-temporal Databases, Location-based Services (GPS and positioning, VPS), GIS and Geo-visualization, Trends in Spatial Database, Recent Researches on Spatial Informatics

Spatial Databases: A Tour, S. Shekhar and S. Chawla, Prentice Hall, 2003, ISBN 013-017480-7
Spatial Computing, The MIT Press Essential Knowledge series, 2020
Encyclopedia of GIS, Springer, 2nd Edition, 2017, ISBN 978-3 319-17884-8
Selected articles from the following journal and conferences:

- *IEEE Transactions on Geoscience and Remote Sensing (TGRS)*
- *ACM Transactions on Spatial Algorithms and Systems (TSAS)*
- *Transactions in GIS, Wiley*

IT838: Quantum Cryptography **(3-0-2) 4**

Introduction to Quantum Computation: Quantum bits, Bloch sphere representation of a qubit, multiple qubits, and design of quantum circuits. Quantum Information: Comparison between classical and quantum information theory, Single photons, EPR pairs, no cloning theorem, Bell states, Quantum teleportation. Quantum Cryptography: Quantum Key Distribution, BB84 Protocol, Graph states and codes, 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.
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.

IT890 Professional Practice / Seminar **2**

This is a 2 credit mandatory learning course to be completed during the 2nd semester. Each student will make technical presentation with suitable demonstration and Professional (Industry) Practices on a topic of academic interest as per recommendations and evaluation criteria of the DPGC of IT department.

IT891/IT897 Practical Training / Minor Project **2**

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

IT898 Major Project-I **4**

The students individually will select a project work based on a topic of interest under the supervision of project guide. This project work will be commencing in the 3rd semester and will be continued in 4th semester. At the end of each semester, the project will be evaluated internally and externally as per the evaluation criteria decided by the DPGC of IT department.

IT899 Major Project-II **6**

The students individually will select a project work based on a topic of interest under the supervision of project guide. This project work will be commencing in the 3rd semester and will be continued in 4th semester. At the end of each semester, the project will be evaluated internally and externally as per the evaluation criteria decided by the DPGC of IT department.