

M.S. in Artificial Intelligence

Non-Credit courses			Elective Courses		
Course Code	Course Title	Credit Hours	Course Code	Course Title	Credit Hours
CS-408	Introduction to Artificial Intelligence	----	CS-5106	Natural Language Processing	3 + 0
Compulsory Courses			CS-5107	Computer Vision	
Course Code	Course Title	Credit Hours	CS-5108	Embedded Intelligence	3 + 0
CS-5101	Advanced Artificial Intelligence	3 + 0	CS-5109	Heuristics and Optimization	3 + 0
CS-5102	Machine Learning	3 + 0	CS-5110	Sentiment Analysis	3 + 0
CS-5103	Mathematics for Artificial Intelligence	3 + 0	CS-5111	Augmented and Virtual Reality	3 + 0
CS-5104	Intelligent Systems Design	3 + 0	CS-5112	Automatic Speech Recognition	3 + 0
CS-5105	Deep Learning	3 + 0	CS-5113	Visual Computing	3 + 0
			CS-5114	Neuro-computation	3 + 0
			CS-5115	Advanced Image Processing	3 + 0
			CS-5116	Human-Robot Interaction	3 + 0
			CS-5117	Artificial Intelligence in Cybersecurity	3 + 0
			CS-5118	Advanced Tools and Frameworks for Artificial Intelligence	3 + 0
			CS-5119	Ethics in Artificial Intelligence	3 + 0
			CS-552	Data Analytics	3 + 0
			CS-562	Big Data Computing	3 + 0
			CS-563	Business Intelligence	3 + 0
			CS-566	Data Mining	3 + 0
			CS-5120	Deep Reinforcement Learning	3 + 0
			CS-5121	Computational Creativity	3 + 0
			CS-5122	Probabilistic Graphical Models	3 + 0
			CS-5123	Multi-agent and Complex Adaptive Systems	3 + 0
			CS-5124	Pattern Recognition	3 + 0

M.S. in Artificial Intelligence

Non-Credit courses			Elective Courses		
Course Code	Course Title	Credit Hours	Course Code	Course Title	Credit Hours
			CS-5125	Knowledge Representation and Reasoning	3 + 0
			CS-5126	Semantic Web	3 + 0
			CS-5127	Information Retrieval	3 + 0
			CS-5128	Artificial Neural Networks	3 + 0
			CS-5129	Internet of Things	3 + 0
			CS-5130	Serious Games	3 + 0
			CS-5002	Thesis	6 + 0

CS-408 Introduction to Artificial Intelligence		
Cr. Hrs.	Contact Hrs.	Exam Marks
-	3	100
-	-	-
Intelligence, Computational Intelligence, Intelligent Agents, Solving Problem by searching, Searching Strategies, Local search Algorithms and Optimization Problems, Knowledge Representation, Reasoning with Imperfect Knowledge, Rule-Based Systems, Modeling Reasoning Strategies, Learning with Complete Data, Regression and Classification, Decision Trees, Artificial Neural Networks, Evolutionary Computing, Genetic Algorithms.		
Recommended book(s) for the approved course		
Text book:		
<ol style="list-style-type: none"> 1. Russell & Norvig, "Artificial Intelligence – A Modern Approach", 3rd edition, Pearson, 2016 2. Mariusz Flasiński, "Introduction to Artificial Intelligence", Springer 2016 		

CS-5101 Advanced Artificial Intelligence			
	Cr. Hrs.	Contact Hrs.	Exam Marks
Th.	3	3	100
Pr.	-	-	-
Intelligent Agents, Adversarial Search, Constraint Satisfaction Problem, Logical Agent, First-Order Logic, Inference in First Order Logic, Quantifying Uncertainty, Probabilistic Reasoning, Probabilistic Reasoning over Time, Utility Theory, Making Complex Decisions, Game Theory, Learning from Examples, Artificial Neural Networks, Support Vector machines, Decision Trees, Learning Probabilistic Models, Learning with Hidden Variables, Deep Learning, Natural Language Processing, Computer Vision, Robotics, Case Studies.			
Recommended book(s) for the approved course			
Text book:			
<ol style="list-style-type: none"> 1. Stuart J. Russell, Peter Norvig, "Artificial Intelligence – A Modern Approach", 3rd Edition, Pearson, 2016. 2. Daphne Koller and Nir Friedman, "Probabilistic Graphical Models", MIT Press, 2009 			

-5102 Machine Learning

	Cr. Hrs.	Contact Hrs.	Exam Marks
Th.	3	3	100
Pr.	-	-	

The Learning Problem, Components of Learning, Types of Learning, Learning Feasibility, Linear Models, Linear Classification and Regression, Logistic Regression, Non-Linear Transformation; Error and Noise, Error Measures and Noisy Targets, Training vs. Testing, Theory of Generalization, The Vapnik-Chervonenkis (VC) Dimension, Definition, VC Dimension of Perceptrons, Interpreting VC Dimension, Generalization Bounds; Bias-Variance Tradeoff, Neural Networks: Stochastic Gradient Descent, Backpropagation Algorithm, Overfitting, Regularization, Validation, Model Selection and Cross Validation.

Recommended book(s) for the approved course

Text book:

1. Miroslav Kubat, "An Introduction to Machine Learning", 2nd edition, Springer, 2018
2. Yaser S. Abu-Mostafa, Malik Magdon-Ismael, Hsuan-Tien Lin, "Learning from Data", AML Book, 2012
3. Mehryar Mohri, Afshin Rostamizadeh, Ameet Talwalkar, "Foundations of Machine Learning", MIT Press, 2012

CS-5103 Mathematics for Artificial Intelligence

	Cr. Hrs.	Contact Hrs.	Exam Marks
Th.	3	3	100
Pr.	-	-	

Applied Linear Algebra for Artificial Intelligence, Linearly dependency, Matrices, Eigen Values & Eigen Vectors, Computational Geometry, Hyperplane, Convolution in Image Processing, Multi-variate Calculus, Functions, Scalar Derivatives, Gradient, Gradient Algorithms, Probabilistic and Bayesian Reasoning, Bayes Rule, Random Variables, Dimensionality Reduction, Principle Components Analysis & Singular Value Decomposition, Maximum A-Posteriori (MAP) & Maximum Likelihood Estimation (MLE) and Distributions, Empirical Risk Minimization, Parameter Estimation, Density Estimation, Linear Regression and Classification Methods, Optimization Theory.

Recommended book(s) for the approved course

Text book:

1. Marc Peter Deisenroth, A. Aldo Faisal, Cheng Soon Ong, "Mathematics for Machine Learning", 1st edition, Cambridge University Press, 2019
2. Edward A. Bender, "Mathematical Methods in Artificial Intelligence", 1st edition, Wiley, 1996

CS-5104 Intelligent Systems Design			
	Cr. Hrs.	Contact Hrs.	Exam Marks
Th.	3	3	100
Pr.	-	-	
Intelligent Systems, Types of Intelligent Systems and Design Methodology, Intelligent Agents, Rule-based Expert Systems, Neural Networks and Deep Learning, Genetic Algorithms, Fuzzy Logic, Emerging Artificial Intelligence Technologies and Computing Hardware, GPGPUs and Hardware Accelerators, Soft Computing, Web Technologies, Cloud Computing and Fog Computing in Intelligent Systems, Role of IoT in Intelligent Systems Design. Chat Bots, Intelligent Human Machine Interface, Ethics, Case Studies (Autonomous Cars, Robots, Humanoids, Smart Agriculture).			
Recommended book(s) for the approved course			
Text book:			
<ol style="list-style-type: none"> 1. Stuart Russell, "Artificial Intelligence – A Modern Approach", 3rd Edition, Pearson Education, 2015. 2. Management Association, Information Reso (Editor), "Artificial Intelligence: Concepts, Methodologies, Tools, and Applications", 4 Volume Set edition, Information Science Reference, 2016 			
CS-5105 Deep Learning			
	Cr. Hrs.	Contact Hrs.	Exam Marks
Th.	3	3	100
Pr.	-	-	-
Deep Learning (DL), success of DL models, Gradient descent, logistic regression, cost functions, hypotheses and tasks, training data, maximum likelihood based cost, cross entropy, Mean Square Error (MSE) cost, feed-forward networks, Multi-layer Perceptron (MLP), sigmoid units, neuroscience inspiration, Graphics Processing Unit (GPU) training, regularization, Rectified Linear Units (RLUs), dropout, Convolutional neural networks (CNNs), probabilistic methods, Recurrent neural networks (RNNs), attention memory networks, auto encoders, deep generative models, Generative adversarial networks (GANs), Boltzmann Learning.			

Recommended book(s) for the approved course

Text book:

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville, "Deep Learning", Massachusetts Institute of Technology, 2016
2. Andrew W. Trask, "Grokking Deep Learning", Manning Publishing Co., 2019

CS-5106 Natural Language Processing

	Cr. Hrs.	Contact Hrs.	Exam Marks
Th.	3	3	100
Pr.	-	-	-

Natural Language Processing (NLP), Information Extraction Techniques in NLP, Word, Morphology & Lexicons, Language Model & Smoothing, Regular Expression, String Edit Distance Alignment & Noisy Channel, Part of Speech Tag, Content Free Grammar & Hidden Markov Model, Parsing, Probabilistic & Non-probabilistic Model, Parsing Algorithms, Lexical Semantics, Word Embedding/Vector Semantics, Compositional Semantics, Semantic Parsing, Introducing to Different Applications of Natural Language Processing, Deep Learning for NLP components.

Recommended book(s) for the approved course

Text book:

1. Li Deng, Yang Liu, "Deep Learning in Natural Language Processing", 1st edition, Springer-Verlag London, 2018.
2. D. Jurafsky, J.Martin, "Speech & Language Processing", 2nd edition, Pearson Education, 2009.

CS-5107 Computer Vision

	Cr. Hrs.	Contact Hrs.	Exam Marks
Th.	3	3	100
Pr.	-	-	-

Fundamentals of Computer Vision, Geometrical and Optical Image Formation, Vision Systems Design, Basics of Image Processing, Filtering, Edge Detection, Features Detection, Contours, Segmentation, Morphological Operators, Motion Detection, Optical Flow, Object Tracking, Motion Capture, Recognition, Large-Scale Instance Recognition and Retrieval, Category Recognition and Advanced Feature Encoding, Applications (Optical Character Recognition, Facial Recognition, Quality Control, Visual

Feedback, Mapping and Robot Guidance, Activity Monitoring, Motion Estimation, Autonomous Systems).

Recommended book(s) for the approved course

Text book:

1. E.R. Davies, "Computer Vision", 5th edition, Academic Press, 2017.
2. Synder & Qi, "Fundamentals of Computer Vision", Cambridge University Press, 2017.
3. Gustavo Olague, "Evolutionary Computer Vision", Springer, 2016.

CS-5108 Embedded Intelligence

	Cr. Hrs.	Contact Hrs.	Exam Marks
Th.	3	3	100
Pr.	-	-	-

Cyber Physical Systems, Sensing Techniques, Wired and Wireless Sensor Networks, Internet of Things, Internet of Cameras, Development of Embedded Systems with Intelligence, Intelligent Sensor-actuator Systems, Internet of Intelligent Things. Algorithms for Systems with Limited Processing and Communication Resources, Case Studies.

Recommended book(s) for the approved course

Text book:

1. Houbing Song, Danda Rawat, Sabina Jeschke, Christian Brecher, "Cyber-Physical Systems Foundations, Principles and Applications", Elsevier Academic Press, 2017/
2. Danda B. Rawat, Joel J.P.C. Rodrigues, Ivan Stojmenovic, "Cyber-Physical Systems: From Theory to Practice", CRC Press, 2015

CS-5109 Heuristics and Optimizations

	Cr. Hrs.	Contact Hrs.	Exam Marks
Th.	3	3	100
Pr.	-	-	-

Meta-heuristics, Gradient-based Optimization, M Single-State Methods (Hill-Climbing, Simulated Annealing, Tabu Search, Iterated Local Search) M Population-based Methods (The Genetic Algorithm, Particle Swarm Optimization), Representation of an Individual (Vectors, Direct Encoded Graphs, Trees and Genetic Programming, Lists, Rule sets, Bloat),

Parallel Methods; Coevolution; Combinatorial Optimization (Greedy Randomized Adaptive Search Procedures, Ant Colony Optimization, Guided Local Search), Optimization by Model Fitting; Policy Optimization; Relevant Case Studies.

Recommended book(s) for the approved course

Text book:

1. Sean Luke, "Essentials of Metaheuristics", 2nd edition, 2014
2. A.E. Eiben J.E. Smith, "Introduction to Evolutionary Computing", Springer, 2008
3. Mitchell Melanie, "An Introduction to Genetic Algorithms", the MIT Press, 1998.
4. Carlos Coello, Gary B. Lamont, "Evolutionary Algorithms for Solving Multi-Objective Problems (Genetic and Evolutionary Computation)", 2nd edition, Springer, 2007

CS-5110 Sentiment Analysis

	Cr. Hrs.	Contact Hrs.	Exam Marks
Th.	3	3	100
Pr.	-	-	-

Subjectivity Analysis, Text Categorization Concept, Computational Linguistic Concept and Subjectivity Analysis, Sentiment Extraction, Topic Extraction, Product Review, Sentiment Analysis of Comparative Words & Applications, Opinion Retrieval and Spam, Searching for Opinion, Opinion Summarization, Opinion Spam, Document Representation, Text Clustering & Topic Modeling, Social Media and Network Analysis, Characteristics of Social Network, Interconnectivity, Text Visualization, Mathematical and Programming Tools for Visualization of Large Collection of Text Documents.

Recommended book(s) for the approved course

Text book:

1. Charu C. Aggarwal, C.Zhai, "Mining Text Data", 1st edition, Springer-Verlag, 2012
2. D.Jurafsky, J. Martin, "Speech & Language Processing", 2nd Edition, Pearson Education, 2009
3. Christophher D. Manning, Prabhakar Raghavan, Hinrich Schutze, "Introduction to Information Retrieval", 1st Edition, Cambridge University Press, 2007

CS-5111 Augmented and Virtual Reality

	Cr. Hrs.	Contact Hrs.	Exam Marks
Th.	3	3	100
Pr.	-	-	-

Augmented Reality (AR) / Virtual Reality (VR) / Mixed Reality (MR), Design and Art across Digital Realities, Spatial Computing, Modalities for Spatial Computing Devices, Designing for Senses, Sensory Technology, Sensory Design, AR Design Tools and Techniques, Mathematical Modeling 3D and 7D Technologies, Hologram Effect, AR Mappings, Cross Platform Augmented and Virtual Reality Applications. Data Visualization and Artificial Intelligence in Spatial Computing.

Recommended book(s) for the approved course

Text book:

1. Erin Pangilinan, Steve Lukas, Vasanth Mohan, "Creating Augmented and Virtual Realities: Theory and Practice for Next-Generation Spatial Computing", 1st edition, 2019
2. Tom Dieck, MM. Claudia, Jung, Timothy, "Augmented Reality and Virtual Reality", Springer, 2019

CS-5112 Automatic Speech Recognition

	Cr. Hrs.	Contact Hrs.	Exam Marks
Th.	3	3	100
Pr.	-	-	-

History of Automatic Speech Recognition, Speech Signal, Speech Production Process, Approaches to Automatic Speech Recognition, Signal Processing Methods for Speech Recognition, Filter Banks, Linear Predictive Coding (LPC), Vector Quantization and Audio Based Spectral Analysis, Discriminative and Generative Methods in Speech Recognition, Conventional Acoustic Modeling, Gaussian Mixture Model (GMM) and Hidden Markov Model (HMM), Deep Neural Networks Methods in Speech Recognition, Model Initialization Techniques, Training and Decoding Methods, Feature Representation & Discriminative Learning.

Recommended book(s) for the approved course

Text book:

1. L. Rabiner, B.H.Juang, "Fundamentals of Speech recognition", 2nd edition, Pearson Education, 2009.
2. Dong Yu, Li Deng, "Automatic Speech Recognition: A Deep Learning Approach", 1st Edition, Springer-Verlag London, 2015

CS-5113 Visual Computing

	Cr. Hrs.	Contact Hrs.	Exam Marks
Th.	3	3	100
Pr.	-	-	-

Handling with Images and 3D Models, Computer Graphics, Image Processing, Visualization, Computer Vision, Virtual and Augmented Reality, Video Processing, Pattern Recognition, Human Computer Interaction, Machine Learning and Digital Libraries, Acquisition, Processing, Analysis and Rendering of Visual Information (mainly Images and Video), Industrial Quality Control, Medical Image Processing and Visualization, Surveying, Robotics, Multimedia Systems, Virtual Heritage, Special Effects in Movies and Television, and Computer Games.

Recommended book(s) for the approved course

Text book:

1. Aditi Majumder and M. Gopi, "Introduction to Visual Computing: Core Concepts in Computer Vision, Graphics, and Image Processing", 1st edition, A Chapman and Hall Book, 2018.
2. Rafael C. Gonzalez Richard E Woods, "Digital Image Processing", 4th edition, Pearson, 2017

CS-5114 Neurocomputation

	Cr. Hrs.	Contact Hrs.	Exam Marks
Th.	3	3	100
Pr.	-	-	-

Dynamical Systems, Phase Portraits, Hodgkin Classification, Bifurcations, Neuro-computational properties, Building Models, Electrophysiology of Neurons, The Hodgkin-Huxley Model, Hodgkin-Huxley Equations, Action Potential, Propagation of the Action potentials, Dendritic Compartments, Simple Models, Integrate-and-Fire, Resonate-and-Fire, Quadratic Integrate – and – Fire, Canonical Models Dendrites Multiple Compartments, The Cable Equation, Branching and Equivalent Cylinders, Isolated Junction, Dendrites with Active Processes.

Recommended book(s) for the approved course

Text book:

1. Eugene M. Izhikevich, "Dynamical Systems in Neuroscience: The Geometry of Excitability and Bursting", The MIT Press, 2007
2. G. Bard Ermentrout, David H. Terman, "Mathematical Foundations of Neuroscience – Interdisciplinary applied mathematics", Springer, 2010.

CS-5115 Advanced Image Processing

	Cr. Hrs.	Contact Hrs.	Exam Marks
Th.	3	3	100
Pr.	-	-	-

Overview of Image and Video Processing, Applications of Image and Video Processing, Color Image Capture and Representation, Color Coordinate Conversion, Spatial Domain Filtering (Linear Convolution, Median and Morphological Filtering), 2D and 3D Discrete-Fourier Transform, Motion Estimation and its Applications, Image and Video Enhancement, Edge Detection, Noise Filtering, Histogram Equalization, Image Recovery Restoration and Super-resolution, Lossless Compression, Image Compression Techniques and Standards, Video Compression Techniques and Standards.

Recommended book(s) for the approved course

Text book:

1. Y. Wang, J. Ostermann, Y.Q.Zhang, "Video Processing and Communications", Prentice Hall, 2002.
2. J.W. Woods, "Multidimensional signal image and video processing and coding," 2nd edition, Academic Press/Elsevier, 2012
3. Rafael C. Gonzalez, Richard Eugene Woods, "Digital Image Processing", Prentice Hall, 2008

CS-5116 Human-Robot Interaction

	Cr. Hrs.	Contact Hrs.	Exam Marks
Th.	3	3	100
Pr.	-	-	-

Designing Computer Interfaces, Cognitivist User Models, Post-cognitivist Perspective, Perceptual Principles, Mental Model Principles, Principles based on Attention, Memory Principles, User Customization, Embedded Computation, Augmented Reality, Social Computing, Knowledge-driven Human-computer Interaction, Emotions and Human-computer Interaction, Brain-computer Interfaces, Activity Theory or Ethnomethodological Accounts of Human Computer Use, Computer Use and HCI Research Practice.

Recommended book(s) for the approved course

Text book:

1. Takayuki Kanda, Hiroshi Ishiguro, "Human-Robot Interaction in Social Robotics", 1st edition, CRC Press, 2013
2. K. Dautenhahn, J. Saunders, "New Frontiers in Human-Robot Interaction", John Benjamins Publishing Company, 2011

CS-5117 Artificial Intelligence in Cyber Security

	Cr. Hrs.	Contact Hrs.	Exam Marks
Th.	3	3	100

Pr.	-	-	-
Cyber Security Concepts, Web Application Security, Advanced Machine Learning Concepts in Cyber Security, Research Methods, Principles and Advanced Technologies, Intelligent Risk Management, Intelligent Techniques for Malware Detection, Statistical Learning for Intrusion Detection Systems (IDS), Intelligent Spam Detection, Intelligent Firewalls, Digital Investigation, Security Events and Information Managements (SEIM), User Behavior Modeling, Case Studies, Neural Computing and Deep Learning for Cyber Security.			
Recommended book(s) for the approved course			
Text book:			
1. Clarence Chio, David Freeman, "Machine Learning and Security: Protecting Systems with Data and Algorithms", 1 st edition, O'Reilly Media, 2018			
2. Leslie F. Sikos, "AI in Cyber Security", 1 st edition, Springer, 2019			
CS-5118 Advanced Tools and Frameworks for Artificial Intelligence			
	Cr. Hrs.	Contact Hrs.	Exam Marks
Th.	3	3	100
Pr.	-	-	-
Implementation Aspects of Artificial Intelligence Models, Algorithmic Designs, Machine Learning Algorithm Designs, Tools for Data Visualization, Data Preprocessing, Machine Learning, Neural Networks, Deep Learning, Data Mining, Network Analysis, Statistical Learning.			
Recommended book(s) for the approved course			
Text book:			
1. S.N. Sivanandam, S. N Deepa, "Introduction to Neural Networks using MATLAB 6.0", Tata McGraw-Hill /Education, 2006			
2. Wei-Meng Lee, "Python Machine Learning", Wiley, 2019			
CS-5119 Ethics in Artificial Intelligence			
	Cr. Hrs.	Contact Hrs.	Exam Marks
Th.	3	3	100
Pr.	-	-	-

Ethics in Artificial Intelligence (AI), Current Initiative in AI and Ethics, Ethics and Empirical Evidence, Normative Ethical Theories, Four Domains of Ethics, Ethical Issues in AI, Methodology for AI Implication, Thinking Procedure for AI in Ethics, Codes for Professional Ethics, Relation, Autonomy

Recommended book(s) for the approved course

Text book:

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville, "Deep Learning", Massachusetts Institute of Technology, 2016
2. Andrew W. Trask, "Grokking Deep Learning", Manning Publishing Co., 2019

CS-5120 Deep Reinforcement Learning			
	Cr. Hrs.	Contact Hrs.	Exam Marks
Th.	3	3	100
Pr.	-	-	-
<p>Reinforcement Learning (RL), Elements of reinforcement learning, Markov Processes, Policy Search and Iteration, Value Iteration, Policy Evaluation, Model Free Learning: Q- Learning and State-Action-Reward- State-Action (SARSA), RL with function approximation, limitation Learning in Large spaces, Exploration/Exploitation, Batch Reinforcement Learning, Deep Q-Networks.</p>			
Recommended book(s) for the approved course			
Text book:			
<ol style="list-style-type: none"> 1. Mohit Sewak, "Deep Reinforcement Learning: Frontiers of Artificial Intelligence", 1st edition, Springer, 2019 2. Richard S. Sutton, Andrew G. Barto, "Reinforcement Learning: An Introduction", 2nd edition, A Bradford Book, 2018 			

CS-5121 Computational Creativity			
	Cr. Hrs.	Contact Hrs.	Exam Marks
Th.	3	3	100

Pr.	-	-	-
Human Creativity in Design and Modeling, Team Creativity, Methods for Studying Creativity, Information- Processing Theories of Human Creativity, Analogical Thinking, Visual Thinking, Knowledge Representation, Systems Thinking, Information- Processing Theories of Creativity in Design and Modeling, Interactive Tools for Augmenting and Amplifying Human creativity, Methods of Evaluating Creativity, Autonomous Computational Systems for Creative Tasks.			
Recommended book(s) for the approved course			
Text book:			
<ol style="list-style-type: none"> 1. Tony Veale, F. Amilcar Cardoso, <i>“Computational Creativity: The Philosophy and Engineering of Autonomously Creative System”</i>, 1st edition, Springer, 2019 2. Tarek R. Besold, Marco Schorlemmer, Alan Amaill, <i>“Computational Creativity Research: Towards Creative Machines”</i>, Atlantis Press, 2015 3. Andrzej P. Wierzbicki, Yoshiteru Nakamori, <i>“Creative Environments: Issues of Creativity Support of the Knowledge Civilization Age”</i>, Springer, 2007 			

CS-5122 Probabilistic Graphical Models			
	Cr. Hrs.	Contact Hrs.	Exam Marks
Th.	3	3	100
Pr.	-	-	-
Introduction, Probability Theory, Bayesian Networks, Undirected Models, Learning Bayes Nets, Exact Inference, Message Passing, Sampling, Maximum A Posteriori (MAP) Inference, Structured Prediction, Parameter Learning, Bayesian Learning, Structure Learning, Exponential Families, Variational Inference.			
Recommended book(s) for the approved course			
Text book:			
<ol style="list-style-type: none"> 1. Luis Enrique Sucar, <i>“Probabilistic Graphical Models: Principles and Application”</i>, Springer, 2015 2. Daphne Kollar, Nir Friedman, <i>“Probabilistic Graphical Models: Principles and Techniques”</i> 1st edition, The MIT Press, 2009 			

CS-5123 Multi-agent and Complex Adaptive Systems			
	Cr. Hrs.	Contact Hrs.	Exam Marks
Th.	3	3	100
Pr.	-	-	-

Foundations, Intelligent Agents and Multi-agent Systems, Multi-agent Learning Social Choice, Mechanism Design, Multi-agent Resource Allocation, Coalition Game, Overview of Complex Adaptive Systems (CAS), Properties of CAS, Cellular automata, social Systems, Evolution of Cooperation, Emergence, Self- organization, Swarm Intelligence, Social Networks.

Recommended book(s) for the approved course

Text book:

1. Yoav Shoham, Kevin Leyton-Brown, *“Multiagent Systems: Algorithmic, Game Theoretic, and Logical Foundation”*, Cambridge University Press, 2008
2. Claudius Gros, *“Complex and Adaptive Dynamical Systems: A Primer”*, 2nd edition, Springer, 2011
3. Melanie Mitchell, *“Complexity: A Guided Tour”*, 1st edition, Oxford University Press, 2011

CS-5124 Pattern Recognition

	Cr. Hrs.	Contact Hrs.	Exam Marks
Th.	3	3	100
Pr.	-	-	-

Bayesian Decision Theory, Bayesian Networks, Maximum Likelihood Estimation (MLE), Dimensionality Reduction, Feature Selection, Bayesian Estimation, Linear Discriminant Functions, Support Vector Machines, Expectation Maximization Algorithm, and Non-parametric Estimation. String Matching, Bias and Variance, Bagging and Boosting, and Unsupervised Learning Clustering.

Recommended book(s) for the approved course

Text book:

1. Christopher M. Bishop, *“Pattern Recognition and Machine Learning”*, revised edition, Springer, 2016
2. Geoff Dougherty, *“Pattern Recognition and Classification: An Introduction”*, Springer, 2013
3. Richard O. Duda, Peter E. Hart, David G. Stock, *“Pattern Classification”*, 2nd edition, John Wiley & Sons, Inc., 2001

CS-5125 Knowledge Representing and Reasoning

	Cr. Hrs.	Contact Hrs.	Exam Marks
Th.	3	3	100
Pr.	-	-	-

Propositional Logic, Sysntax and Semantics of Propositional Logic, Proof by Resolution and Automated theorem, first-order Logic, Syntax and Semantics of first-order Logic, Forward and Backward chaining, Semantic Nets, Inheritance in Taxonomies, Approaches and Issues (in Predicate Logic, fuzzy Logic, weak and strong Slot and Filler Structures), Knowledge Acquisition, the Frame Problem, Symbolic Reasoning under Uncertainty (Non-monotonic Reasoning Augmenting a Problem Solver), Statistical reasoning, Building Knowledge based Systems.

Recommended book(s) for the approved course

Text book:

1. Gerardus Blokdyk, *“Knowledge Representation and Reasoning”, 3rd edition, Emereo Pty Limited, 2018*
2. Arvind Ramanath Neelakantan, *“Knowledge Representation and Reasoning with Deep Neural Networks”, University of Massachusetts Libraries, 2017*
3. Ronald Brachman, Hector Levesaque, *“Knowledge Representation and Reasoning”, Elsevier, 2004*

CS-5126 Semantic Web

	Cr. Hrs.	Contact Hrs.	Exam Marks
Th.	3	3	100
Pr.	-	-	-

Resource Description Framework (RDF) and Linked Data, Ontologies, the RDF Query Language SPARQL, RDF Triplestores, Understanding Datasets, Basic Web Ontology Language (OWL) Modeling, Creating Ontologies, Ontology Design Patterns (ODPs), ODP based Modeling, Description Logics, Onotology-alignment and Debugging, Constraints in RDF, Data Quality and Data Cleaning in RDF.

Recommended book(s) for the approved course

Text book:

1. Miltiadis D. Lytras, Naif Aljohani, Emesto Damiani, Kwok Tai Chui, *“Semantic Web Science and Real-World Applications”, IGI Global, 2019.*
2. Sandeep Kumar, Niyati Baliyan, *“Semantic Web-Based System: Quality Assessment Models”, Springer 2018*
3. Amit Sheth, *“Semantic Web: Ontology and Knowledge Base Enabled Tools, Services, and Application”, Information Science Reference, 2013*

CS-5127 Information Retrieval

	Cr. Hrs.	Contact Hrs.	Exam Marks
Th.	3	3	100
Pr.	-	-	-

Search Engine Architecture, Information Retrieval (IR) Models, Retrieval Evaluation, Relevance Feedback, Link Analysis, Search Applications, Retrieval System Design and Implementation, Text Analysis Techniques, Retrieval Models (Boolean, Vector Space, Probabilistic, and Learning-based Methods), Search Evaluation, Retrieval Feedback, Search Log Mining, and Applications in Web Information Management, IR Techniques for Web, Crawling, Link-based Algorithms, and Metadata.

Recommended book(s) for the approved course

Text book:

1. Tie-Yan Liu, *“Learning to Rank for Information Retrieval”*, Springer Berlin Heidelberg, 2014
2. Carol Peters, Martin Braschler, Paul Clough, *“Multilingual Information Retrieval: From research to Practice”* Springer, 2012
3. Baeza-Yates Ricardo and Berthier Ribeiro-Neto, *“Modern Information Retrieval”, 2nd edition, Addison-Wesley, 2011*

CS-5128 Artificial Neural Networks

	Cr. Hrs.	Contact Hrs.	Exam Marks
Th.	3	3	100
Pr.	-	-	-

Neuron Models and Basic Learning Rules, Learning of a Single Neuron and a Single-Layered Neuron, Multilayer Neuran Networks and Back-Propagation, Associative Memory, Self Organizing Feature Map, Radial Basis Function (RBF) Neural Networks and Support Vector Machines (SVM), and Neural Network Trees

Recommended book(s) for the approved course

Text book:

1. Tariq Rshid, *“Make Your Own Neural Network: A Gentle Journey Through the Mathematics of Neural Networks and Making Your Own Using the Python Computer Language”*, CreateSpace Independent Publishing Platform, 2016
2. Martin T. Hagan, Howard B. Demuth, Mark Hudson Beale, De Jesus, Orlando, *“Neural Network Design”, 2nd edition, Martin Hagan, 2014*
3. Giuseppe Ciaburro, Balaji Venkateswaran, *“Neural Networks with R. Smart models using CNN, RNN, deep learning, and artificial intelligence principles”*, Packt Publishing, 2017

CS-5129 Internet of Things

	Cr. Hrs.	Contact Hrs.	Exam Marks
Th.	3	3	100
Pr.	-	-	-

Internet-of-Things (IoT), applications of IoT (Smart Building, Healthcare, Agriculture, Urban Infrastructure, Transportation, Assistive Tracking for the Blind), Fundamental Design Issues for the Future Internet, Differences between Internet and Internet-of-things, Design Issues of Internet-of-Things, research Challenges, Primer on Transmission Control Protocol/Internet Protocol (TCP/IP) Stack, Wireless Network Protocol, Medium Access Control, Comparative Study of ZigBee, Bluetooth, Ultra Wide Band (UWB), Wi-Fi, and Radio Frequency Identification (RFID), Capillary Networks, Data Aggregation, IPv6 Low Power Personal Area Network (6LoWPAN) Architecture, Routing Protocol in Lossy Network (RPL), Performance Analysis and Evaluation in TinyOS, Directed Acyclic Graph (DAG) Construction, Parent-child Relationship, Objective Function, Minimum Rank with Hysteresis, constrained Application Protocol (CoAP)

Recommended book(s) for the approved course

Text book:

1. Rajkumar Buyya, Amir Vahid Dastjerdi, *“Internet of Things: Principals and Paradigms”*, 1st edition, Morgan Kaufmann, 2016

CS-5130 Serious Games

	Cr. Hrs.	Contact Hrs.	Exam Marks
Th.	3	3	100
Pr.	-	-	-

Ethical Considerations of using Games to Change Behavior, Game Interfaces, Universal Design, Research Methodologies for Game Interactions, Game Telemetry, Game Metrics, Artificial Intelligence Evaluation Techniques for Big Data from Game Telemetry, Evaluation Techniques for Games Research, Case Studies (Application of Games in Health, Military, Education and Art).

Recommended book(s) for the approved course

Text book:

1. Ralf Dorner, Stefan Gobel, Wolfgang Effelsberg, Josef Wiemeyer, *“Serious Games, Foundations, Concepts and Practice”*, 1st edition, Springer, 2016
2. Ute Ritterfeld, Michael J. Cody, Peter Vorderer, *“Serious Games: Mechanisms and Effects”*, Routledge Publications, 2009
3. Katie Salen, Eric Zimmerman, *“Rules of Play: Game Design Fundamentals”*, The MIT Press, 2003
4. James Paul Gee, *“What Video Games Have to Teach Us About Learning and Literacy”*, 2nd edition, St. Martin’s Press, 2014