Indian Institute of Space Science and Technology
Thiruvananthapuram - 695547

M.Tech in Machine Learning and Computing

Department : Mathematics, IIST
Duration: 4 Semesters
Intake: 10 Students (4-Students from DOS/ISRO & 6-Students from outside (GATE score required in the relevant area))

<table>
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<th>Curriculum</th>
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<tr>
<td><strong>1st Semester</strong></td>
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<td><strong>Code</strong></td>
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<td>MA611</td>
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<td>MA631</td>
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<td><strong>Total credits</strong></td>
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| **2nd Semester** |
| **Code** | **Course title** | **Lecture** | **Tutorial** | **Practical** | **Credits** |
| MA621 | Discrete Mathematics | 3 | 0 | 0 | 3 |
| MA622 | Pattern Recognition and Machine Learning | 3 | 0 | 1 | 4 |
| MA623 | Computer Modeling and Simulation | 3 | 0 | 1 | 4 |
| E01 | Elective - I | 0 | 0 | 0 | 3 |
| E02 | Elective - II | 0 | 0 | 0 | 3 |
| MA641 | Software Lab - II | 0 | 0 | 2 | 2 |
| **Total credits** | | **9** | **0** | **4** | **19** |

| **3rd Semester** |
| **Code** | **Course title** | **Lecture** | **Tutorial** | **Practical** | **Credits** |
| MA851 | Seminar | 0 | 0 | 0 | 2 |
| MA711 | Self Study Course | 3 | 0 | 0 | 3 |
| MA712 | Comprehensive Viva | 0 | 0 | 0 | 2 |
| MA852 | Project Phase - I | 0 | 0 | 0 | 7 |
| **Total credits** | | **3** | **0** | **0** | **14** |

| **4th Semester** |
| **Code** | **Course title** | **Lecture** | **Tutorial** | **Practical** | **Credits** |
MA 611 Optimization Techniques 3-0-0=3

Optimization: Need for unconstrained methods in solving constrained problems, Necessary conditions of unconstrained optimization, Structure methods, Quadratic models, Methods of line search, Steepest descent method, Quasi-Newton methods: DFP, BFGS, Conjugate-direction methods, Methods for sums of squares and nonlinear equations

Linear Programming: Simplex Methods, Duality ii LPP, Transportation problem

Nonlinear programming: Lagrange Multiplier, KKT conditions, Convex programing

Texts:


References:


MA 612 Applied Statistics 3-0-0=3

Review of Probability distribution and statistical inference, design of experiments, Single factor, Randomized block, Lotin square.
Regression, linear, multiple, curvilinear, nonparametric texts, sign, signed rank, randomness and other parametric tests.

Statistical Quality control, Control for charts for measurements and for attributes. Tolerance limits, Acceptance Sampling. Reliability and life testing.

**MA 613  Data Mining 3-0-1=4**

Introduction to datamining concepts; linear methods for regression; classification methods: k-nearest neighbour classifiers, decision tree, logistic regression, naive Bayes, Gaussian discriminant analysis; regularized cost function; model evaluation & selection; unsupervised learning: association rules; apriori algorithm, FP tree, cluster analysis, self organizing maps, google page ranking; dimensionality reduction methods: supervised feature selection, PCA; ensemble learning: bagging, boosting, adaBoost; outlier mining; imbalance problem; multi class classification; introduction to semi supervised learning, transfer learning, active learning, data warehousing.

**References**


**MA 614  Matrix Computation  2-0-1=3**

Floating point computations, IEEE floating point arithmetic, analysis of roundoff errors; Sensitivity analysis and condition numbers; Linear systems, LU decompositions, Gaussian elimination with partial pivoting; Banded systems, positive definite systems, Cholesky decomposition - sensitivity analysis; Gram-Schmidt orthonormal process, Householder transformation, Givens rotations; QR factorization, stability of QR factorization. Solution of linear least squares problems, normal equations, singular value decomposition(SVD), polar decomposition, Moore-Penrose inverse; Rank deficient least-squares problems; Sensitivity analysis of least-squares problems; Review of canonical forms of matrices; Sensitivity of eigenvalues and eigenvectors. Reduction to Hessenberg and tridiagonal forms; Power, inverse power and Rayleigh quotient iterations; Explicit and implicit QR algorithms for symmetric and nonsymmetric matrices; Reduction to bidiagonal form; Golub- Kahan algorithm for computing SVD.

**Texts:**

References:


MA 616 Evolutionary and Natural Computing 3-0-1=4


References


MA 631 - Software Lab 0-0-2=2

Use MATLAB, Maple, SPSS, GPSS and other application software package to model of simultaneous equations, eigen value, eigen vector, system of linear and non- linear differential equations, stability analysis, numerical integration, regression, analysis, etc., Graphical methods.
2nd Semester

MA 621 - Discrete Mathematics  3-0-0=3


Undirected and direct graphs, modelling with graphs, trials and cycles, connectivity and trees.

Graph algorithms: BFS, DFS, shortest path, optimal spanning trees, matching, job assignment problem, optimal transportation through flows in networks.

Texts:

References:

MA 622 - Pattern Recognition and Machine Learning  3-0-1=4

Kernel Methods: Introduction to metric space, vector space, normed space, inner product space; RKHS; Learning theory; SVM for classification & regression; implementation techniques of SVM; kernel ridge regression; kernel density estimation; kernel PCA; kernel online learning.

Spectral Clustering; model based clustering, Expectation Maximization; Independent Component Analysis; Hidden Markov models; Factor Analysis; introduction to Graphical models & Sampling Methods.

References:
MA 623 - Computer Modeling and Simulation       3-0-1=4

Meaning and importance of simulation and modelling, classification of models, Variables and problem formulation, performance measures, Data collection and analysis, SIMSCRIPT language concept: general syntax, Discrete event modelling, process and resources, timing and pending list, accumulate and tally, process instance and object oriented aspects, sets and data structures, Probability distribution, Random number and random variant generation. Input modelling and output analysis. Generation of graphical output, user interface and animation in SIMSCRIPT, development of simulation models of real system through integration of programming and statistical concepts, issues related to credibility of models.

Electives

MA 861 - Computer Vision and Image Processing       2-0-1=3


Computer Vision: Discrete geometry and quantization, Length estimations, Automated visual inspection, Object recognition and matching, Depth perception problems, Stereo geometry and correspondence, Motion analysis, Optical flow, Applications of Computer Vision, Remote sensing, Biomedical imaging, Document processing, Target tracking.

MA 862 - Artificial Neural Networks and Intelligent Agents       2-0-1=3

Foundations of Biological Neural Networks and Artificial Neural Networks (Learning, Generalization, Memory, Abstraction, Applications), McCulloch-Pitts Model, Historical Developments. ANN Architectures, Learning Strategy (Supervised, Unsupervised, Reinforcement), Applications: Function Approximation, Prediction, Optimization.

Associative Memories: Matrix memories, Bidirectional Associative Memory, Hopfield Neural Network. Neural Architectures with Unsupervised Learning: Competitive learning, Principal Component Analysis Networks (PCA), Kohonen’s Self-Organizing Maps, Linear Vector Quantization, Adaptive Resonance Theory (ART) Networks, Independent Component Analysis Networks (ICA).

Logic: Prepositional Calculus and Predicate Calculus, Satisfiability and Validity, Notions of Soundness and completeness.

**MA866 - Control Theory**  
2-0-1=3


Observability: Continuous Systems, Duality, Multiple Input Systems.


**References**


**MA867 - Reinforcement Learning**  
2-0-1=3

The Reinforcement Learning problem; Dynamic programming; Monto-Carlo Methods; Temporal Difference learning; Eligibility traces; Function Approximation; Planning and Learning; Dimensions of Reinforcement Learning

**Text Book**