Semesterwise detailed course structure

Semester I					
Course No.	Course Title	L	T	P	C
MA 589	Statistical Foundations for Data Science	3	0	0	6
MA 579H	Scientific Computing	3	0	0	3
MA 580H	Matrix Computations	3	0	0	3
CS 591H	Data Structures and Algorithms	3	0	0	3
CS 592H	Databases	3	0	0	3
XX ddd	Elective – I	3	0	0	6
CS 593	Data structures and Databases Lab	0	0	3	3
MA 581	Numerical Computations Lab	0	0	3	3
CS 594	Python Programming Lab	0	0	3	3
Total		12	0	9	33

Semester II					
Course No.	Course Title	L	T	P	C
EE 595H	Stochastic Models	3	0	0	3
EE 596H	Optimization Techniques	3	0	0	3
EE 526	Machine Learning	3	0	0	6
XX ddd	Elective II	3	0	0	6
XX ddd	Elective III	3	0	0	6
EE 527	Machine Learning Lab	0	0	3	3
MA 588	R Programming Lab	0	0	3	3
CS 595	Data Visualization Lab	0	0	3	3
Total		12	0	9	33

Semester III					
Course No.	**Course Title**	**L**	**T**	**P**	**C**
DS 698	Project - I	**0**	**0**	**24**	**24**
Total		**0**	**0**	**24**	**24**

Semester IV					
Course No.	**Course Title**	**L**	**T**	**P**	**C**
DS 699	Project - II	**0**	**0**	**24**	**24**
Total		**6**	**0**	**24**	**24**

Core Courses Syllabi

Course Number & Title: **MA 589 Statistical Foundations for Data Science**
L-T-P-C: **3-0-0-6**
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): **Regular Letter Grades**
Kind of Proposal (New Course / Revision of Existing Course): **New Course**
Offered as (Compulsory / Elective): **Compulsory**
Offered to: **M.Tech. (DS)**
Offered in (Odd/ Even / Any): **Odd**
Offered by (Name of Department/ Center): **Mathematics**
Pre-Requisite: **None**
Course Contents: Probability spaces, conditional probability, independence; Random variables, distribution functions, probability mass and density functions, functions of random variables, standard univariate discrete and continuous distributions; Mathematical expectations, moments, moment generating functions, inequalities; Random vectors, joint, marginal and conditional distributions, conditional expectations, independence, covariance, correlation, standard multivariate distributions, functions of random vectors; Law of large numbers, central limit theorem. Sampling distributions; Point estimation - estimators, minimum variance unbiased estimation, maximum likelihood estimation, method of moments, consistency; Interval estimation; Testing of hypotheses - tests and critical regions, likelihood ratio tests; Linear regression.
Texts/References: B. L. S. Prakasa Rao, A First Course in Probability and Statistics, World Scientific/Cambridge University Press India, 2009. R. V. Hogg, J. W. McKean and A. Craig, Introduction to Mathematical Statistics, 6th Ed., Pearson Education India, 2006.

Course Number & Title: **MA 579H Scientific Computing**
L-T-P-C: **3-0-0-3**
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): **Regular Letter Grades**
Kind of Proposal (New Course / Revision of Existing Course): **New Course**
Offered as (Compulsory / Elective): **Compulsory**
Offered to: **M.Tech. (DS)**
Offered in (Odd/ Even / Any): **Odd**
Offered by (Name of Department/ Center): **Mathematics**
Pre-Requisite: **None**
Definition and sources of errors, solutions of nonlinear equations; Bisection method, Newton's method and its variants, fixed point iterations, convergence analysis; Newton's method for non-linear systems; Finite differences, polynomial interpolation; Numerical integration - Trapezoidal and Simpson's rules, Gaussian quadrature; Initial value problems - Taylor series method, Euler and modified Euler methods, Runge-Kutta methods.
Texts/References: D. Kincaid and W. Cheney, Numerical Mathematics and Computing, 7th Edn., Cengage, 2013. K. E. Atkinson, Introduction to Numerical Analysis, 2nd Edn., John Wiley, 1989.

Course Number & Title: **MA 580H Matrix Computations**
L-T-P-C: **3-0-0-3**
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): **Regular Letter Grades**
Kind of Proposal (New Course / Revision of Existing Course): **New Course**
Offered as (Compulsory / Elective): **Compulsory**
Offered to: **M.Tech. (DS)**
Offered in (Odd/ Even / Any): **Odd**
Offered by (Name of Department/ Center): **Mathematics**
Pre-Requisite: **None**
Course Contents: Linear systems – All variants of Gaussian elimination and LU factorization, Cholesky factorization. Linear least-squares problem - Normal equations, rotators and reflectors, QR factorization via rotators, reflectors and Gram Schmidt orthonormalisation, QR method for linear least-squares problems, rank deficient least-squares problems. Singular value decomposition (SVD) – numerical rank determination via SVD, solution of least squares problems, Moore- Penrose inverse, low rank approximations via SVD, Principal Component Analysis, applications to data mining and image recognition. Eigenvalue Decomposition - Power, inverse power and Rayleigh quotient iterations, Schur's decomposition, unitary similarity transformation of Hermitian matrices to tridiagonal form, QR algorithm, implementation of explicit QR algorithm for Hermitian matrices.
Texts/References: L. N. Trefethen and David Bau, Numerical Linear Algebra, SIAM, Philadelphia, 1997. D. S. Watkins, Fundamentals of Matrix Computation, 2nd Edition, Wiley, 2002. L. Elden Matrix Methods in Data Mining and Pattern Recognition, SIAM, Philadelphia, 2007.

Course Number & Title: **CS 591H Data Structures and Algorithms**
L-T-P-C: **3-0-0-3**
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): **Regular Letter Grades**
Kind of Proposal (New Course / Revision of Existing Course): **New Course**
Offered as (Compulsory / Elective): **Compulsory**
Offered to: **M.Tech. (DS)**
Offered in (Odd/ Even / Any): **Odd**
Offered by (Name of Department/ Center): **Computer Science & Engineering**
Pre-Requisite: **None**
Preamble/Objectives (Optional): Fundamentals of data structures, algorithm build foundations for the students of diverse background
Course Contents: Review of fundamental Data Structures Models of Computation: random access machines, space and time complexity measures, lower and upper bounds Design techniques: the greedy method, divide-and-conquer, dynamic programming, backtracking; Sorting and Searching Graph algorithms Hashing: separate chaining, linear probing, quadratic probing Search Trees: binary search trees, AVL trees, B-trees.
Texts/References: T H Cormen, C E Leiserson, R L Rivest and C Stein, Introduction to Algorithms, 3/e, MIT Press, 2009. Jon Kleinberg and Eva Tardos, Algorithm Design, 1/e, Pearson Education, 2006.

Course Number & Title: **CS 592H Databases**
L-T-P-C: **3-0-0-3**
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): **Regular Letter Grades**
Kind of Proposal (New Course / Revision of Existing Course): **New Course**
Offered as (Compulsory / Elective): **Compulsory**
Offered to: **M.Tech. (DS)**
Offered in (Odd/ Even / Any): **Odd**
Offered by (Name of Department/ Center): **Computer Science & Engineering**
Pre-Requisite: **None**
Preamble/Objectives (Optional): Fundamentals of databases with specific focus on SQL build foundations for the students of diverse background
Course Contents: Data Models: Data models with emphasis on the relational model Database Design: Database design with E-R model, From E-R model to relational database design Algebra: Relational algebra and calculus SQL queries, constraints, triggers Database application development: Stored procedures
Texts/References: R. Ramakrishnan and J. Gehrke, Database Management Systems, 3/e, McGraw Hill, 2003

Course Number & Title: **CS 593 Data Structures and Databases Lab**
L-T-P-C: **0-0-3-3**
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): **Regular Letter Grades**
Kind of Proposal (New Course / Revision of Existing Course): **New Course**
Offered as (Compulsory / Elective): **Compulsory**
Offered to: **M.Tech. (DS)**
Offered in (Odd/ Even / Any): **Odd**
Offered by (Name of Department/ Center): **Computer Science & Engineering**
Pre-Requisite: **None**
Preamble/Objectives (Optional):
Course Contents: Programming assignments are based on the theory courses CS 591H Data Structures and algorithms and CS 592H Databases.
Texts/References: T H Cormen, C E Leiserson, R L Rivest and C Stein, Introduction to Algorithms, 3/e, MIT Press, 2009. Jon Kleinberg and Eva Tardos, Algorithm Design, 1/e, Pearson Education, 2006. R. Ramakrishnan and J. Gehrke, Database Management Systems, 3/e, McGraw Hill, 2003

Course Number & Title: **CS 594 Python Programming Lab**
L-T-P-C: **0-0-3-3**
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): **Regular Letter Grades**
Kind of Proposal (New Course / Revision of Existing Course): **New Course**
Offered as (Compulsory / Elective): **Compulsory**
Offered to: **M.Tech. (DS)**
Offered in (Odd/ Even / Any): **Odd**
Offered by (Name of Department/ Center): **Computer Science & Engineering**
Pre-Requisite: **None**
Preamble/Objectives (Optional):
Course Contents: Fundamental concepts: Literals, variables and identifiers, operators, expressions and data types; Control structures: Boolean expressions, selection control, iterative control; Lists: List structures, Lists, (sequences), iterating over lists; Functions: Program routines, calling value-returning functions, calling non value-returning functions, parameter passing, variable scope; Dictionaries and Sets; Recursion; Text Files: Using text files, string passing, exception handling;
Texts/References: Charles Dierbach, Introduction to computer science using Python a computational problem solving focus, John-Wiley & Sons, 2012.

Course Number & Title: **MA 581 Numerical Computions Lab**
L-T-P-C: **0-0-3-3**
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): **Regular Letter Grades**
Kind of Proposal (New Course / Revision of Existing Course): **New Course**
Offered as (Compulsory / Elective): **Compulsory**
Offered to: **M.Tech. (DS)**
Offered in (Odd/ Even / Any): **Odd**
Offered by (Name of Department/ Center): **Mathematics**
Pre-Requisite: **None**
Preamble/Objectives (Optional):
Course Contents: Programming assignments are based on the theory courses MA 579H Scientific Computing and MA 580H Matrix Computation.
Texts/References: L. N. Trefethen and David Bau, Numerical Linear Algebra, SIAM, 1997. D. S. Watkins, Fundamentals of Matrix Computation, 2nd Edn., Wiley, 2002. D. Kincaid and W. Cheney, Numerical Analysis: Mathematics of Scientific Computing, 3rd Edn., AMS, 2002. K. E. Atkinson, Introduction to Numerical Analysis, 2nd Edn., John Wiley, 1989.

Course Number & Title: **EE 595H Stochastic Models**
L-T-P-C: **3-0-0-3**
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): **Regular Letter Grades**
Kind of Proposal (New Course / Revision of Existing Course): **New Course**
Offered as (Compulsory / Elective): **Compulsory**
Offered to: **M.Tech. (DS)**
Offered in (Odd/ Even / Any): **Even**
Offered by (Name of Department/ Center): **Electronics and Electrical Engineering**
Pre-Requisite: **None**
Course Contents: Stochastic Processes**:** Definition and classification of random processes; Discrete-time Markov chains; Poisson process; Continuous-time Markov chains; Bayesian statistics; Monte Carlo; Gibbs Sampler: data augmentation, burn-in, convergence; Metropolis-Hastings algorithm: independent sampler, random walk Metropolis, scaling, multi-modality; Approximate Bayesian Computation.
Texts/References: Sheldon M. Ross, Stochastic Processes, Wiley, 1995. W. R. Gilks, S. Richarson and D. Spiegelhalter, Markov chain Monte Carlo methods in Practice, Chapman and Hall.

Course Number & Title: **EE 596H Optimization Techniques**
L-T-P-C: **3-0-0-3**
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): **Regular Letter Grades**
Kind of Proposal (New Course / Revision of Existing Course): **New Course**
Offered as (Compulsory / Elective): **Compulsory**
Offered to: **M.Tech. (DS)**
Offered in (Odd/ Even / Any): **Even**
Offered by (Name of Department/ Center): **Electronics and Electrical Engineering**
Pre-Requisite: **None**
Course Contents: optimization - sequences and limits, derivative matrix, level sets and gradients, Taylor series; unconstrained optimization - necessary and sufficient conditions for optima, convex sets, convex functions, optima of convex functions, steepest descent, Newton and quasi Newton methods, conjugate direction methods; constrained optimization - linear and non-linear constraints, equality and inequality constraints, optimality conditions, constrained convex optimization, projected gradient methods, penalty methods
Texts/References: E. K. P. Chong and S. H. Zak, *An Introduction to Optimization*, 2nd Edn., Wiley India Pvt. Ltd., 2010. D. G. Luenberger and Y. Ye, *Linear and Nonlinear Programming*, 3rd Edn., Springer, 2010.

Course Number & Title: **EE 526 Machine Learning**
L-T-P-C: **3-0-0-6**
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): **Regular Letter Grades**
Kind of Proposal (New Course / Revision of Existing Course): **New Course**
Offered as (Compulsory / Elective): **Compulsory**
Offered to: **M.Tech. (DS)**
Offered in (Odd/ Even / Any): **Even**
Offered by (Name of Department/ Center): **Electronics and Electrical Engineering**
Pre-Requisite: **None**
Course Contents: Introduction to learning; Bayesian Classification; Feature Selection; PCA; K-Means Clustering; DBSCAN; Hierarchical Agglomerative Clustering; GMM; Mean-shift Clustering; Multilayer Perceptron; RBF Networks; Classification Performance Analysis; Decision Trees; SVM; Introduction to Multiple Kernel Learning; Ensemble Methods – Bagging and Boosting, Hidden Markov Models; Introduction to CNN and RNN; Introduction to Reinforcement Learning
Texts/References: E. Alpaydin, *Introduction to Machine Learning*, 3rd Edition, Prentice Hall (India) 2015. R. O. Duda, P. E. Hart and D. G. Stork, *Pattern Classification*, 2nd Edn., Wiley India, 2007. C. . Bishop, *Pattern Recognition and Machine Learning (Information Science and Statistics)*, Springer, 2006. S. O. Haykin, *Neural Networks and Learning Machines*, 3rd Edition, Pearson Education (India), 2016 J. Shawe-Taylor and Nello Cristianini, *Kernel Methods for Pattern Analysis*, Cambridge University Press, 2004. I. Goodfellow, Y. Bengio , A. Courville, *Deep Learning*, MIT Press, 2017 R. Sutton, *Reinforcement Learning – An Introduction*, MIT Press, 1998 Relevant Research Papers in the area of Machine Learning

Course Number & Title: **EE 527 Machine Learning Lab**
L-T-P-C: **0-0-3-3**
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): **Regular Letter Grades**
Kind of Proposal (New Course / Revision of Existing Course): **New Course**
Offered as (Compulsory / Elective): **Compulsory**
Offered to: **M.Tech. (DS)**
Offered in (Odd/ Even / Any): **Even**
Offered by (Name of Department/ Center): **Electronics and Electrical Engineering**
Pre-Requisite: **None**
Course Contents: Design of experiments in Machine Learning; Introduction to popular Machine Learning Datasets and Toolkits; Face Recognition using PCA; Practical applications of clustering; Experiments on supervised classification using MLP, RBF ANN, SVM and Decision Trees; Application of Classifiers Ensembles; Sequence classification using HMM; Applications of CNN and RNN; Path planning with Reinforcement Learning
Texts/References:

Course Number & Title: **MA 588 R Programming Lab**
L-T-P-C: **0-0-3-3**
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): **Regular Letter Grades**
Kind of Proposal (New Course / Revision of Existing Course): **New Course**
Offered as (Compulsory / Elective): **Compulsory**
Offered to: **M.Tech. (DS)**
Offered in (Odd/ Even / Any): **Even**
Offered by (Name of Department/ Center): **Mathematics**
Pre-Requisite: **None**
Course Contents: Introduction to R: basic commands, graphics, indexing data, loading data; Regression: linear regression, test of significane, residual analysis, polynomial regression, qualitative predictor, logistic-regression; Resampling methods: crossvalidation, bootstrap; Subset selection: best subset selection, foward and backward stepwise selection, choosing among models using the validation; Markov chain monte carlo. Optimization in R: Common R Packages for Linear, Quadratic and Non-linear optimization, Built-in Optimization functions, Linear Programming in R: lpsolve, Quadratic Programming: quadprog,Non-Linear Optimization: One-Dimensional: Golden Section Search; Multi-dimensional: Gradient-based, Hessian based, Non-gradient based
Texts/References: An Introduction to Statistical Learning: with Applications in R (Springer Texts in Statistics), G. James, D. Witten, T. Hastie and R. Tibshirani, Springer, 2013. A First Course in Statistical Programming with R, W John Braun, Duncan J Murdoch, Cambridge University Press 2008. https://cran.r-project.org/web/views/Optimization.html

Course Number & Title: **CS 595 Data Visualization Lab**
L-T-P-C: **0-0-3-3**
Type of Letter Grading (Regular Letter Grades / PP or NP Letter Grades): **Regular Letter Grades**
Kind of Proposal (New Course / Revision of Existing Course): **New Course**
Offered as (Compulsory / Elective): **Compulsory**
Offered to: **M.Tech. (DS)**
Offered in (Odd/ Even / Any): **Even**
Offered by (Name of Department/ Center): **Computer Science & Engineering**
Pre-Requisite: **None**
Course Contents: Defining data visualization; Visualization workflow: describing data visualization workflow, process in practice; Data Representation: chart types: categorical, hierarchical, relational, temporal & spatial; 2-D: bar charts, Clustered bar charts, dot plots, connected dot plots, pictograms, proportional shape charts, bubble charts, radar charts, polar charts, Range chart, Box-and-whisker plots, univariate scatter plots, histograms word cloud, pie chart, waffle chart, stacked bar chart, back-to-back bar chart, treemap and all relevant 2-D charts. 3-D: surfaces, contours, hidden surfaces, pm3d coloring, 3D mapping; multi-dimensional data visualization; manifold visualization; graph data visualization; Annotation;
Texts/References: Andy Kirk, Data Visualization A Handbook for Data Driven Design, Sage Publications, 2016 Philipp K. Janert, Gnuplot in Action, Understanding Data with Graphs, Manning Publications, 2010.

Elective Courses

Course ID	Title	Credits
Elective Offered by CSE		
CS508	Optimization Methods	3-0-0-6
CS511	Learning With Kernels	3-0-0-6
CS534	Approximation Algorithms	3-0-0-6
CS561	Artificial Intelligence	3-0-0-6
CS562	Machine Learning	3-0-0-6
CS565	Intelligent Systems And Interfaces	3-0-0-6
CS566	Speech Processing	3-0-0-6
CS567	Pattern Recognition	3-0-0-6
CS568	Data Mining	3-0-0-6
CS569	Multimedia Systems	3-0-0-6
CS570	Fundamentals of Information Retrieval	3-0-2-8
CS572	Computations Systems Biology	3-0-0-6
CS573	Data Analysis For Machine Learning	1-0-4-6
CS574	Computer Vision Using Machine Learning	3-0-0-6
CS529	Topics and Tools in Social Media Data Mining	3-0-0-6
CS539	Machine Learning Using Cloud Computing	2-0-3-7
CS576	Advanced Topics in Artificial Intelligence	3-0-0-6
Electives Offered by EEE		
EE624	Image Processing	3-0-0-6
EE625	Computer Vision	3-0-0-6
EE626	Biomedical Signal Processing	3-0-0-6
EE627	Speech Signal Processing and Coding	3-0-0-6
EE657	Pattern Recognition For Machine Learning	3-0-0-6
EE660	Biometrics	3-0-0-6
EE664	Introduction to Parallel Computing	3-0-0-6
EE692	Detection and Estimation Theory	3-0-0-6
Electives Offered by Mathematics		
MA504	Combinatorial Optimization	3-0-0-6
MA544	Wavelets and Applications	3-0-0-6
MA562	Mathematical Modeling and Numerical Simulation	3-0-0-6

MA576	Large Scale Scientific Computation	3-0-0-6
MA577	Perturbation Methods	3-0-0-6
MA593	Statistical Methods and Time Series Analysis	3-0-0-6
MA601	Graphs and Matrices	3-0-0-6
MA681	Applied Stochastic Processes	3-0-0-6
MA682	Statistical Inference	3-0-0-6
MA691	Advanced Statistical Algorithms	3-0-0-6