Suggested Teaching Guidelines for

Mathematics & Statistics for Artificial Intelligence
PG-DAI February 2025

Duration: 40 Classroom hours

Objective: To reinforce knowledge of general Aptitude, Mathematics, and Statistics concepts

Prerequisites: Knowledge of basic of Mathematics.

Evaluation method: Theory exam– 80% weightage
Internal exam– 20% weightage

List of Books / Other training material

Reference Book:

1. An Introduction to Statistical Learning: with Applications in R by Daniela Witten, Gareth James, Robert Tibshirani, and Trevor Hastie ISBN 9781461471387
2. Advanced Engineering Mathematics by Erwin Kreyszig, ISBN 978-8126531356
3. Linear Algebra by Jim Hefferon, ISBN- 978-1944325039
4. Higher Engineering Mathematics by B V Ramana ISBN - 978-0070634190
5. The elements of Statistical Learning: Data Mining, Inference & Prediction by Trevor Hastie, Jerome Friedman

Note:

- ***Each session mentioned is of 2 hours duration for theory.***
- ***Faculty is advised to relate the mathematical concepts with some application in real world scenarios***
- ***Faculty is advised to relate the topics with machine learning algorithms***

Linear Algebra

Session 1 & 2
Lecture

- Vectors, Definition,
- Scalars, Addition, Scalar Multiplication
- Inner Product (Dot Product), Vector Projection
- Cosine Similarity, Orthogonal Vectors

Session 3 & 4
Lecture

- Normal And Orthonormal Vectors
- Vector Norm, Vector Space
- Linear Combination, Linear Span
- Linear Independence, Basis Vectors

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Assignments: Consider the vectors {[3, 0, 4], [−1, 0, 7], [2, 9, 11]} .Check that the vectors are linearly independent or not ?

Session 5

Lecture

- Linear Independence
- Basis and Rank
- Linear Mappings
- Affine Spaces

Session 6 & 7

Lecture

- Matrices Definition, Addition, Transpose
- Scalar Multiplication, Matrix Multiplication, Matrix Multiplication Properties
- Hadamard Product, Functions, Linear Transformation, Determinant, Identity Matrix,
- Invertible

Assignments: $X = [0\ 1\ 3]^T$ and $Y = [2\ \ 4\ 0]^T$

- Find V = Subspace of X
- Find W = Subspace of Y
- Describe V intersection W ?

Session 8 & 9

Lecture

- Matrix and Inverse, Rank, Trace
- Popular Type of Matrices- Symmetric, Diagonal, Orthogonal, Orthonormal
- Positive Definite Matrix
- Matrix Phylogeny
- Matrix Approximation

Session 10 & 11

Lecture

- Eigen Values & Eigenvectors, Concept, Intuition, Significance
- How To Find Principle Component Analysis
- Concept, Properties, Applications
- Singular Value Decomposition

Assignments: Find the eigen values and eigenvectors for the matrix

$$\begin{bmatrix} 5 & -10 & -5 \\ 2 & 14 & 2 \\ -4 & -8 & 6 \end{bmatrix}$$

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Calculus

Session 12 & 13

Lecture

- Functions, Scalar Derivative, Definition, Intuition
- Common Rules Of Differentiation, Chain Rule

Session 14 & 15

Lecture

- Partial Derivatives, Gradient
- Concept, Intuition, Properties
- Directional Derivative

Assignments: Let $f(x,y,z)=xyex2+z2−5$f(x,y,z)=xyex2+z2−5. Calculate the gradient of ff at the point (1,3,−2)(1,3,−2) and calculate the directional derivative DufDuf at the point (1,3,−2)(1,3,−2) in the direction of the vector v=(3,−1,4)v=(3,−1,4).

Session 16 & 17

Lecture

- Gradients of Vector Valued Functions
- Gradient of Matrices
- Useful Identities for Computing Gradients
- Back propagation and Automatic Differentiation
- Linearization and Multivariate Taylor Series

Session 18

Lecture

- Optimization Using Gradient Descent
- Constrained Optimization and Lagrange Multipliers
- Convex Optimization

Session 19

Lecture

- Vector And Matrix Calculus
- How To Find Derivative Of Scalar-Valued
- Vector-Valued Function With Respect To Scalar, Vector , Four Combinations- Jacobian

Session 20

Lecture

- Gradient Algorithms, Local/Global Maxima and Minima
- Saddle Point, Convex Functions
- Gradient Descent Algorithms- Batch, Mini-Batch, Stochastic
- Performance Comparison