Math for Machine Learning – Subtopics Guide

1■■ Linear Algebra (Used in data representation, model computations, and neural networks)

- Scalars, Vectors, Matrices, Tensors – definitions & notation, shape & dimensions
- Vector Operations – addition, subtraction, scalar multiplication
- Matrix Operations – addition, multiplication, transpose
- Dot Product – vector dot product, applications in similarity (cosine similarity in NLP)
- Matrix Multiplication – row × column rule, used in neural network forward pass
- Identity & Inverse Matrices – solving linear systems
- Determinant & Rank – understanding matrix properties
- Eigenvalues & Eigenvectors – dimensionality reduction (PCA)
- Norms – L1, L2 norms (used in regularization)
- Special Matrices – diagonal, symmetric, orthogonal

2■■ Statistics & Probability (Used in model evaluation, understanding uncertainty, and data analysis)

- Descriptive Statistics – mean, median, mode, variance, standard deviation, range, quartiles
- Probability Basics – events, outcomes, probability rules (addition, multiplication)
- Conditional Probability – Bayes' theorem, Naive Bayes classifier
- Probability Distributions – normal (Gaussian), binomial, Poisson
- Random Variables – discrete vs continuous
- Sampling Techniques – random, stratified sampling
- Hypothesis Testing – null & alternative hypothesis, p-values, t-tests
- Correlation & Covariance – relationship between features
- Central Limit Theorem – foundation for many ML algorithms

3■■ Calculus (Used in optimization, training models, and backpropagation)

- Functions & Limits – understanding function behavior
- Derivatives – basic rules (power, sum, product, quotient)
- Partial Derivatives – multi-variable functions, key in gradient descent
- Gradient – vector of partial derivatives, optimization in ML
- Chain Rule – backpropagation in neural networks
- Higher-Order Derivatives – second derivatives (Hessian matrix)
- Maxima & Minima – finding optimal values
- Gradient Descent Algorithm – learning rate, convergence
- Jacobian & Hessian – advanced optimization