

AiTI PhD Entrance Syllabus

Detailed Syllabus

Unit 1 General Aptitude and Communication: Weightage: 15 %

- Verbal aptitude including grammar vocabulary in context sentence correction reading comprehension inference argument structure and narrative sequencing
- Quantitative aptitude including ratios percentages averages powers exponents logarithms sequences permutations combinations elementary geometry mensuration estimation and numerical comparison
- Analytical reasoning including deduction induction analogy syllogisms statement and conclusion numerical relations pattern recognition and constraint-based puzzles
- Data interpretation using tables bar charts line graphs pie charts scatter plots maps and two-dimensional or three-dimensional plots
- Spatial aptitude including translation rotation scaling mirroring assembling grouping paper folding cutting and simple two-dimensional or three-dimensional patterns

Unit 2 Research Aptitude Methodology and Ethics: Weightage: 5%

- Research foundations including the meaning and purpose of research problem identification objectives research questions hypotheses constructs and operational definitions
- Research approaches including quantitative qualitative mixed-method experimental quasi-experimental observational survey case study and design science approaches at an introductory level
- Literature review including search strategy source evaluation synthesis identification of a research gap and use of primary and secondary sources
- Variables and measurement including independent dependent control and confounding variables nominal ordinal interval and ratio scales reliability validity bias and uncertainty
- Sampling and data collection including population sample probability and non-probability sampling sample representativeness questionnaires interviews observations experiments documents and existing datasets
- Study planning including comparison groups controls randomization replication reproducibility and the limits of inference from a chosen design

- Evidence and interpretation including association and causation internal and external validity generalizability effect size practical significance and responsible reporting of negative or inconclusive findings
- Research integrity including citation plagiarism fabrication falsification selective reporting authorship peer review conflicts of interest and reproducible records
- Ethics in data and AI research including informed consent privacy data protection anonymization fairness accountability transparency and risks to people or communities
- Academic communication including the structure of an abstract proposal article thesis and technical report and interpretation of methods results tables and figures

Unit 3 Engineering Mathematics for AI: Weightage: 20%

- Discrete mathematics including propositions truth tables predicates sets relations functions equivalence and order relations elementary proof and counting principles permutations combinations recurrence concepts and basic graph terminology
- Linear algebra including vectors matrices matrix operations determinant inverse rank systems of linear equations linear independence basis eigenvalues eigenvectors orthogonality projections positive semidefinite matrices and the concepts of LU decomposition and singular value decomposition
- Calculus including functions limits continuity differentiation integration basic Taylor expansion partial derivatives gradients chain rule and maxima and minima
- Optimization including objective and constraint concepts unconstrained single variable and simple multivariable optimization convexity at an introductory level Lagrange multipliers for simple constraints and the idea of gradient descent
- Numerical foundations including approximation finite precision absolute and relative error roots of simple equations and numerical solution of small systems of linear equations

Unit 4 Probability Statistics and Data Interpretation: Weightage: 20%

- Descriptive statistics including data types frequency distributions mean median mode range variance standard deviation percentiles and interquartile range
- Probability including sample spaces events probability axioms addition and multiplication rules independence conditional probability total probability and Bayes theorem

- Random variables and distributions including probability mass and density functions cumulative distribution functions expectation variance and Bernoulli binomial Poisson uniform exponential and normal distributions
- Joint data including marginal and conditional distributions covariance correlation and the distinction between correlation and causation
- Sampling and inference including sampling distributions standard error the central limit theorem confidence intervals and the logic of null and alternative hypotheses p values Type I and Type II errors and z t and chi square tests at an introductory level
- Modelling and experimental data including simple linear regression interpretation of coefficients residuals goodness of fit and the basic purpose of randomization blocking and one-way analysis of variance
- Data quality and visual interpretation including missing values outliers sampling bias misleading graphs and selection of an appropriate summary or visualization

Unit 5 Programming Algorithms and Data Management: Weightage: 20%

Programming questions should use Python 3-style syntax or language-neutral pseudocode. Any nonstandard operation must be defined in the question. Questions should test reasoning about programs rather than memorization of library-specific syntax.

- Programming basics including variables data types operators expressions input and output conditional statements loops functions parameters return values scope and simple recursion
- Core data objects including numbers Boolean values strings arrays or lists tuples sets dictionaries or maps and elementary operations on them
- Program reasoning including tracing code identifying errors selecting test cases decomposing a problem into functions and estimating output for a given input
- Data structures including arrays linked lists stacks queues hash tables trees binary search trees heaps and graphs at a foundational level
- Algorithms including linear and binary search elementary sorting merge sort quicksort tree and graph traversal shortest path concepts and basic greedy and divide-and-conquer reasoning
- Complexity including comparison of constant logarithmic linear linearithmic and quadratic time and simple space complexity

- Data management including files tabular data entity and relationship concepts keys relational tables basic normalization and SQL using SELECT WHERE ORDER BY GROUP BY aggregate functions and simple JOIN operations
- Data preparation including encoding categories scaling normalization discretization sampling training validation and test set separation and prevention of data leakage

Unit 6 Artificial Intelligence and Machine Learning Foundations

Weightage: 20%

- AI problem formulation including agents states actions goals constraints search spaces features targets labels and the distinction between prediction description and decision making
- Search and reasoning including breadth first search depth first search uniform cost search informed search heuristic functions A star search adversarial search concepts propositional logic predicate logic and introductory reasoning under uncertainty
- Learning paradigms including supervised unsupervised semi-supervised and reinforcement learning at a conceptual level and appropriate use cases for classification regression clustering and dimensionality reduction
- Core supervised methods including simple and multiple linear regression logistic regression k-nearest neighbors naive Bayes decision trees support vector machines and the concepts of ensemble learning
- Core unsupervised methods including k-means hierarchical clustering principal component analysis and interpretation of clusters or components
- Model development including training validation testing cross-validation feature selection hyperparameters underfitting overfitting bias-variance trade-off and regularization concepts
- Evaluation including confusion matrix accuracy precision recall sensitivity specificity F1 score receiver operating characteristic and area under the curve and regression measures including mean absolute error mean squared error root mean squared error and coefficient of determination
- Neural network foundations including perceptrons multilayer feed-forward networks activation functions loss functions gradient descent and the purpose of backpropagation
- Introductory deep learning and generative AI including the basic roles of convolution sequence modelling attention embeddings foundation models and the

difference between generative and discriminative tasks without architecture-specific derivations

- Introductory natural language processing and computer vision including text and image representations classification feature extraction and selection of suitable evaluation measures
- Trustworthy and responsible AI including fairness bias privacy security robustness transparency explainability accountability human oversight hallucination and responsible use of data and models
- Applied reasoning including selection of suitable data features model validation strategy and evaluation measure for a short AI scenario in agriculture health energy finance cybersecurity robotics or another domain


Abhijit Singh

Prasen Datta

Ranee Handana Lal

Approved by DRC


Saran Mahato

Approved by Dean, AITI