YSU Department of Mathematics and Mechanics

Applied Statistics and Data Science

Master's Program

Entrance Exam Material Coverage

1 Calculus

1. Continuous functions and their properties: Intermediate Value Theorem (Cauchy intermediate value theorem), Extreme Value Theorem (Weierstrass theorem)
2. Big-O and small-o notations
3. Differentiation of a univariate function: differentiation rules, the derivative of elementary functions, the derivative of a composite function (the chain rule); Mean Value Theorem (Lagrange Mean Value Theorem); Monotonicity; Extrema of functions, necessary and sufficient conditions; Tangent lines; Derivative of the inverse function
4. L'Hôpital's rule, Convexity, Curve Sketching
5. Indefinite Integrals: List of Elementary Integrals; Integration by Parts and Substitution
6. Definite Integrals: Fundamental Theorem of Calculus (Newton-Leibnitz Formula), Calculation of areas and volumes by integrals;
7. Improper Integrals
8. Numerical and functional series, Convergence tests; Positive and Alternating series; Absolute and Conditional convergence; Power Series, Taylor series
9. Multivariate Calculus: The $\mathbb{R}^n$ space; Partial Derivatives, the chain rule; Tangent planes; Unconstrained Optimization; Constrained Optimization and Lagrange Multipliers
10. Double Integrals; Jacobians, change of Variable in Double Integral

Bibliography You can use any of your favorite Calculus (Mathematical Analysis) books or online materials. Some suggestions are:

- Stewart J., Calculus, 8th edition, 2016
- Fikhtengolts G., Differential and Integral Calculus Course, in 3 parts, 10th edition, 2016 (in Russian)

2 Linear Algebra

1. Systems of Linear Equations, Gaussian elimination;
2. Vectors in $\mathbb{R}^n$, Linear combinations, Linear Dependence and Independence; Bases in Vector Spaces and Dimension;
3. Matrices, operations with Matrices, the determinant of a square Matrix, Inverse of a square Matrix; Rank of a Matrix; Eigenvalues and Eigenvectors;
4. Linear Transformations
5. Lines and Planes in $\mathbb{R}^2$ and $\mathbb{R}^3$

Bibliography Here again, you can use any of your favorite Linear Algebra books or online materials. Some suggestions are:

- Strang G., Introduction to Linear Algebra, 5th edition, 2016
- Strang G., Linear Algebra, MIT Course, MIT OpenCourseWare
- Poole D., Linear Algebra: A Modern Introduction, 4th edition, 2014

3 Probability Theory

1. Probability Measure and its properties
2. Discrete Probability Spaces: Experiments with Equally Likely Outcomes, Combinatorial Probability Problems, Geometric Probabilities;
3. Conditional Probabilities; The Total Probability Formula and the Bayes Formula;
4. Random Variables: The Cumulative Distribution Function (CDF) and the Probability Density (Mass) Function (PD(M)F); Calculation of probabilities using the CDF or the PD(M)F;
5. Some Well-Known Distributions: Bernoulli and Binomial Distributions; Geometric and Poisson Distribution; Uniform Distribution; Exponential Distribution and the Normal (Gaussian) Distribution
6. Expectation and Variance of a random variable: Calculation of the Expected value and the Variance through PD(M)F
7. Transformations of Random Variables
8. Joint Distribution of Random Variables, Joint CDF and Joint PD(M)F
9. Independent RVs, Covariance and Correlation Coefficient
10. Chebyshev Inequality, The Law of Large Numbers and the Central Limit Theorem

Bibliography Here again, you can use any of your favorite Probability books or online materials. Some suggestions are:

- Ross Sh., A First Course in Probability, 9th edition, 2014
- Shiryaev A., Probability, 5th edition, 2011 (in Russian)

4 Programming and Algorithmic Thinking

No specific Programming Language will be required. The algorithms will be given/requested to write in pseudocode.