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Preparatory Math Course Outline

The Preparatory Math Course aims to equip students with the necessary math background for the first year (compulsory) economics graduate level courses. It is mainly meant to be a refresher of existing math knowledge. Below is a list of the topics that will be covered separated into themes. Students who feel unfamiliar with some of these topics are encouraged to read up on them prior to the start of the course. A useful set of references is provided at the end of the syllabus.

Topic 1: Sets, Proofs and Functions

- Logical operators, De Morgan's laws

- Methods of proof: Induction, Deduction, Contradiction

- Functions, Mappings: surjective, injective, bijective

Topic 2: Metrics, Sequences and Limits

- Euclidean space: field definition, the Real number system, Cartesian product, Euclidean distance

- Metrics

- Vector norms

- Open and closed sets, open and closed spheres

- Sequences: convergent sequences, sequences in $\mathbb{R}$, subsequences in $\mathbb{R}$, Cauchy sequences

- Contraction mapping theorem

- Limits of functions

- Continuity of functions, extreme and intermediate value theorems, monotonic functions

- Infinite limits

- Mathematical paradoxes

Topic 3: Matrix Algebra

- Vector interpretation, span, basis, orthogonality

- Basic matrix operations: summation, multiplication, transpose, trace, determinant, rank, inverse

- Eigenvalues and eigenvectors

- Matrix decompositions: eigendecomposition, Jordan decomposition, Cholesky decomposition

- Orthogonal matrices

- Definite matrices

- Matrix operators: Kronecker product, matrix vectorization

Topic 4: Calculus

- Differentiation: definition, implicit differentiation, Taylor series, power series

- Maximization

- Integration: indefinite integral, definite integral, integration by parts, by substitution

- Differential equations

- Multivariate differentiation: partial derivatives, gradient, Hessian, Jacobian

- Matrix differentiation: rules, directional derivatives

- Multiple integrals

- Constrained optimization: Lagrangian, KKT conditions, Hamiltonian

- Logarithms

- Complex numbers, De Moivre's Theorem

- Homogenous functions

- Implicit/inverse function theorem

Topic 5: Probability and Statistics

- Probability: definition, axioms, properties, conditional probability

- Independent events

- Random variables

- Probability densities: continuous and discrete

- Cumulative densities

- Joint, marginal and conditional distributions

- Change of variable technique

- Expectation, conditional expectation, law of iterated expectations

- Jensen's inequality

- Population and sample moments

- Common distributions

- Frequentist estimation, estimator properties, convergence results

Topic 6: Concavity and Convexity

- Convex sets, convex hull

- Hyperplane

- Hyperplanes, separating hyperplane theorem

- Concave functions, convex functions

- Concavity, quasiconcavity

- Correspondence, hemicontinuity

Notes

To prepare you can make use of the following references: Chiang & Wainwright (2005), De la Fuente (2000), (Hamilton, 1994, Appendix), Judge, Hill, Griffiths, Lütkepohl & Lee (1988), (Lucas, Stokey & Prescott, 1989, Chapter 3), (Mas-Colell, Whinston & Green, 1995, Appendix),(Barro & Sala-i Martin, 2003, Appendix) Simon & Blume (1994). You can also find all of the topics online on Wikipedia, Wolfram Mathworld or other sites.

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