Mathematics Foundation Outline

Aim & Scope

- Coverage of the Maths up to Grade 12 Matric or AS Level necessary for data structures, algorithms and data science
- 6 sessions
- In each session:
    - Students will be given a worked example/exemplar
    - Lecturer will teach the basics of how to solve the problem in the given example
    - Lecturer to provide students with steps to success/cheat sheet on how to solve the "problems" on their own
    - Lecturer will provide guidance on how to use existing computing devices like Wolfram to help students practise and check their work
    - Students can then practise and check “homework problems” in their own time

Lecture 1: Sets, Functions and Variables

- Define sets and create sets using roster and interval notation
- Define a function as a mapping between a domain and codomain and distinguish between single-variable and multivariate functions.
- Describe functions in terms of variables, equations and graphs
- Use a computing device to use special functions such as the log function

Lecture 2: Linear Algebra

- Explain the structure and differences between vectors and matrices
- Use vectors and matrices to model quantities that the students are familiar with. An example could be the direction and speed that a vehicle is going in.
- Perform scalar and dot arithmetic operations of vectors and matrices
- Use a computing device to map vectors and matrices to planes on a graph

Lecture 3: Probability

- Define and explain fundamental concepts such as sample space, events, and probabilities
- Explain and demonstrate basic probability calculations, including addition and multiplication rules, as well as concepts of conditional probability and independence.
- Define common probability distributions like the uniform, binomial, and normal distributions and explain their properties, applications, and how they model real-world scenarios.
- Simulate a neural network using probability and linear algebra operations for predictive modelling, emphasising their role in data science and algorithmic decision-making.

Lecture 4: Combinations and Permutations

- Explain the difference between a combination and a permutation
- Apply combination and permutation formulas and explain the results of the application
- Apply the probability formulas for combinations and permutations and explain the results of the application

- Use a computing device to calculate the combinations, permutations and their probabilities for finite sets.

Lecture 5: Differentiation

- Define and compute the gradient in the context of linear functions
- Explain the similarities between the concept of a gradient and a derivative
- Apply the process of differentiation for a single-variable function following the rules of differentiation
- Use a computing device to compute the derivative of a single-variable and multivariate functions

Lecture 6: Order Complexity

- Explain the purpose of an asymptote and identify an asymptote in a graph
- Evaluate the worst-case complexity order of a Python-based algorithm, express it using O(n) notation and explain the relevance of the asymptote in the result of the evaluation.
- Compare the worst-case time and space complexities of different algorithms for the same class of problems
- Make tradeoffs between space, time and projected input size when selecting the most appropriate algorithm for a practical use case