# Unit 18: Discrete Maths

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| **Unit code** | **Y/615/1648** |
| **Unit level** | **5** |
| **Credit value** | **15** |

## Introduction

Digital computer technologies operate with distinct steps, and data is stored within as separate bits. This method of finite operation is known as 'discrete', and the division of mathematics that describes computer science concepts such as software development, programming languages, and cryptography is known as 'discrete mathematics'. This branch of mathematics is a major part of computer science courses and ultimately aids in the development of logical thinking and reasoning that lies at the core of all digital technology.

This unit introduces students to the discrete mathematical principles and theory that underpin software engineering. Through a series of case studies, scenarios and tasked-based assessments students will explore set theory and functions within a variety of scenarios; perform analysis using graph theory; apply Boolean algebra to applicable scenarios; and finally explore additional concepts within abstract algebra.

Among the topics included in this unit are: set theory and functions, Eulerian and Hamiltonian graphs, binary problems, Boolean equations, Algebraic structures and group theory.

On successful completion of this unit students will be able to gain confidence with the relevant discrete mathematics needed to successfully understand software engineering concepts. As a result they will develop skills such as communication literacy, critical thinking, analysis, reasoning and interpretation, which are crucial for gaining employment and developing academic competence.

### Learning Outcomes

By the end of this unit students will be able to:

LO1. Examine set theory and functions applicable to software engineering.

LO2. Analyse mathematical structures of objects using graph theory.

LO3 Investigate solutions to problem situations using the application of Boolean algebra.

LO4. Explore applicable concepts within abstract algebra.

## Essential Content

LO1 **Examine set theory and functions applicable to software engineering**

*Set theory:*

Sets and set operations.

Algebra within set theory.

Set identities and proof of identities.

Bags manipulation functions.

*Functions:*

*Domain, range and mappings.*

*Inverse relations and the inverse function.*

*Injective, surjective and transitive functions.*

LO2 **Analyse mathematical structures of objects using graph theory**

*Graph theory:*

Structure and characterisation of graphs.

Spanning trees and rooted trees.

Eulerian and Hamiltonian graphs.

Vertex and edge colourings of graphs.

*Directed graphs:*

Directed and directed graphs.

Walks, trails, paths and shortest paths.

LO3 **Investigate solutions to problem situations using the application of Boolean algebra**

*Boolean algebra:*

Binary states (e.g. on/off; 1/0; open/closed; high/low).

Identification of binary problems and labelling inputs and outputs.

Produce a truth table corresponding to a problem situation.

*Equations:*

Express a truth table as a Boolean equation.

Simplify a Boolean equation using algebraic methods.

Represent a Boolean equation using logic gates.

LO4 **Explore applicable concepts within abstract algebra**

*Algebraic structures:*

Binary operations and associated properties.

Commutative and associative operations.

Algebraic structures and substructures.

*Groups:*

Introduction to groups, semigroups and monoids.

Families of groups and group codes.

Substructures and morphisms.

## Learning Outcomes and Assessment Criteria

<table>
<tr><th>Pass</th><th>Merit</th><th>Distinction</th></tr>
<tr><td colspan="2">LO1 Examine set theory and functions applicable to software engineering</td><td rowspan="2">D1 Formulate corresponding proof principles to prove properties about defined sets.</td></tr>
<tr><td>P1 Perform algebraic set operations in a formulated mathematical problem.<br>P2 Determine the cardinality of a given bag (multiset).</td><td>M1 Determine the inverse of a function using appropriate mathematical techniques.</td></tr>
<tr><td colspan="2">LO2 Analyse mathematical structures of objects using graph theory</td><td rowspan="2">D2 Construct a proof of the Five Colour Theorem.</td></tr>
<tr><td>P3 Model contextualised problems using trees, both quantitatively and qualitatively.<br>P4 Use Dijkstra's algorithm to find a shortest path spanning tree in a graph.</td><td>M2 Assess whether an Eulerian and Hamiltonian circuit exists in an undirected graph.</td></tr>
<tr><td colspan="2">LO3 Investigate solutions to problem situations using the application of Boolean algebra</td><td rowspan="2">D3 Design a complex system using logic gates.</td></tr>
<tr><td>P5 Diagram a binary problem in the application of Boolean Algebra.<br>P6 Produce a truth table and its corresponding Boolean equation from an applicable scenario.</td><td>M3 Simplify a Boolean equation using algebraic methods.</td></tr>
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| Pass | Merit | Distinction |
|---|---|---|
| **LO4** Explore applicable concepts within abstract algebra | | **D4** Prepare a presentation that explains an application of group theory relevant to your course of study. |
| **P7** Describe the distinguishing characteristics of different binary operations that are performed on the same set.<br><br>**P8** Determine the order of a group and the order of a subgroup in given examples. | **M4** Validate whether a given set with a binary operation is indeed a group. | |

## Recommended Resources

### Textbooks

Attenborough, M. (2003) *Mathematics for Electrical Engineering and Computing*. Oxford: Newnes.

Piff, M. (2008) *Discrete Maths Software Engineers: An Introduction for Software Engineers*. Cambridge: Cambridge University Press.

### Journals

*Journal of Graph Theory. Wiley*

*Journal of Mathematical Modelling and Algorithms in Operations Research. Springer*

### Links

This unit links to the following related units:

*Unit 11: Maths for Computing*

*Unit 22: Applied Analytical Models*