Unit 47: Advanced Data Representation and Manipulation for IT

Unit code: F/601/3246

QCF Level 3: BTEC Specialist

Credit value: 7

Guided learning hours: 60

Aim and purpose

This unit introduces mathematical concepts (matrices, series and graphs) and their application to the development of computer programs.

Unit introduction

To work effectively as an IT professional, individuals need to have mathematical knowledge and be able to apply this knowledge. The purpose of this unit is to provide an introduction to a number of key mathematical ideas, to provide opportunities to develop useful skills and techniques and for learners to be able to apply them in different areas of IT.

The unit starts by looking at matrices, covering basic matrix operations, how matrices are used in computer science and how matrices can be used to tackle mathematical problems.

The next learning outcome starts arithmetic and geometric series. Learners will learn how to generate series and perform simple operations on them. They will then move on to recursion, using recursion methods to generate series and applying recursion to computing problems.

The unit then moves on to consider probability, looking at probability events and ways of expressing them in diagrammatic and mathematical formats.

The final learning outcome of the unit is graph theory, where learners will investigate graph data structures and use graph theory methods to represent and process data with computers.

Learning outcomes and assessment criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria determine the standard required to achieve the unit.

On completion of this unit a learner should:

Learning outcomes	Assessment criteria
1 Be able to apply matrix methods	1.1 explain matrices as a method of representing ordered data and their relationship with computer program variable arrays 1.2 use index notation to reference the cells of a matrix 1.3 perform add, subtract, and scalar multiplication operations on a matrix 1.4 multiply two matrices 1.5 find: • the inverse of a matrix by elementary row operations • the transpose of a matrix 1.6 apply matrix techniques to a range of applications including: • solving simultaneous linear equations • vector transformation and rotation • maps and graphs
2 Be able to apply series, probability and recursions	2.1 give a functional expression for a series 2.2 express a series recursively 2.3 find the sum of a series 2.4 express probabilities as percentages, fractions and decimals 2.5 apply series, probability and recursion techniques to develop a solution to a range of problems

Learning outcomes	Assessment criteria
3 Be able to apply graph theory	3.1 describe the components of a graph and their properties 3.2 explain the characteristics of undirected, directed and mixed graphs 3.3 represent a set of connected objects as a graph 3.4 describe the type of problem which can be modelled by a weighted graph

Unit content

1 Be able to apply matrix methods

Matrices: method of representing ordered data; relationship with computer program variable arrays; index notation

Operations: add, subtract, scalar multiplication; multiply two matrices; inverse; transpose

Techniques: solving simultaneous linear equations; vector transformation and rotation; maps and graphs, graph data structures

2 Be able to apply series, probability and recursions

Sequences and series: finding the Nth term of a sequence; generation of recurrence relationship; arithmetic and geometric sequences and series; sum to n terms of an arithmetic and geometric series; sum to infinity of a geometric series; Σ notation

Recursion: series eg Fibonacci, factorial, natural numbers; termination condition; recursive algorithms to solver problems eg factorials, quicksort, binary search

Probability: events eg union, intersection, complementary, mutually exclusive, independent; space diagrams eg sum of scores when two dice are thrown; visualising events using Venn diagrams; tree diagrams, expressing probability as percentages, fractions and decimals

3 Be able to apply graph theory

Graph data structures: terms eg vertex (or node), edge (or arc), loop, degree, adjacent, path, circuit, planar, directed (edges have directions), undirected (edges do not have directions), mixed (only some edges have directions); connectivity, connected and component; weighted graphs eg for shortest path problems, networks

Representations of graphs in computing: adjacency list and matrix; incidence list and matrix

Graph handling algorithms: appropriate areas eg graph transformations, network analysis

Essential guidance for tutors

Delivery

The learning outcomes could be delivered in the order presented, however some of the content relates to isolated sets of skills and knowledge and the order could be varied.

It is likely that learners will come to this unit with a wide variety of knowledge and experience. For this reason it is suggested that the unit is flexibly delivered using workshops. This allows all learners to progress and accumulate expertise at different rates and to a different extent.

Necessarily, much of the content at this level is theoretical. Learners might not understand some of the practical applications until they study at a higher level. Where possible, connections with IT-related applications should be made to provide the content of exercises and assignments. It is recommended that any data sets provided should relate to real-life scenarios.

For learning outcome 1 it is important to relate the use of matrices to IT, for example in areas such as computer graphics where matrices can be used to project three-dimensional objects onto two-dimensional computer screens and in electronics where circuit components and their input/output voltages and resistance can be represented by matrices.

Learning outcome 2 leads to recursion and recursive algorithms used in programming. Examples include calculating factorials and using search and sort programmes. These could be demonstrated using an appropriate programming language or using pseudo code.

Learning outcome 3 covers graph theory and its application in computer science. Learners will represent graphs as computer data structures and use them to store information and to solve simple problems.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments. The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Introduction to the unit
Assignment 1 - Matrix methods
Be able to apply series, probability and recursions: • whole-class exercise – tutor presentation on expressing series as functions and recursions, followed by practical exercises • whole-class exercise – tutor presentation on probability, as fractions, percentages and decimals, followed by practical exercises • whole-class exercise – tutor presentation on the use of series, probability and recursion in a range of different situations, followed by individual exercises.
Assignment 2 - Serious problems **Assignment 3** - An exercise in probability **Assignment 4** - Finding a solution
Be able to apply graph theory: • whole-class exercise – tutor presentation on graph theory, including characteristics and components of graphs, followed by individual exercises • whole-class exercise – tutor presentation on representing connected objects in graphs, followed by individual exercises • whole-class exercise – tutor presentation on weighted objects in graphs, followed by individual exercises.
Assignment 5 - Graph theory

Assessment

It is suggested that this unit is assessed using the five assignments summarised in the *Programme of suggested assignments* table.

Finding a scenario which covers all aspects of all criteria is difficult, but the one suggested in the programme of suggested assignments table is acceptable. It may be appropriate to use prepared exercises to provide evidence for some of the criteria in this unit, but it is recommended, that where possible, these be set into a vocational context. Exercises could be included in one or more assignments to be completed to a deadline, but centres are advised that timed tests or examinations would be outside the scope of the unit, which does not require calculations to be completed against the clock.

Any exercises used must be assessed by the tutor against the relevant criteria in the learning outcomes and assessment criteria table, informed by the range of unit content and must not be marked in terms of numerical (eg x/10) or percentage achievement. Where the unit content asks for a particular set of calculations to be completed, then all calculations must be completed successfully and it is expected that workings be shown where appropriate. Care must be taken that activities are completed individually and that there is no scope for the sharing of answers between learners.

It is inevitable that much of this unit will be evidenced on paper or by using a spreadsheet but, where possible, centres are encouraged to vary strategies to include verbal presentations, posters and other forms of visual evidence and to set activities within a vocational context.

Where descriptive or explanatory evidence is required by a particular criterion, appropriate observation records completed by both the learner and tutor may form part of the evidence.

All three learning outcomes could be assessed in a similar way, with learners producing material for technical audiences specified either by learners or the tutor.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass criteria in the outcomes and assessment grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment methods
1.1, 1.2, 1.3, 1.4, 1.5, 1.6	Matrix methods	A company has asked you to put together a brief guide to matrices. The guide should explain what matrices are and how basic operations are carried out, giving worked examples. The company would like you to support your brief guide by demonstrating how matrix operations can solve problems.	Booklet. Posters. A set of mathematical tasks.

Criteria covered	Assignment title	Scenario	Assessment methods
2.1, 2.1, 2.3	Serious problems	A company has asked you to create a presentation on sequences and series. The presentation should explain how to express both arithmetic and geometric series as functions and as recursion. It should also include some worked examples showing how to sum a series and how to find its Nth term.	Booklet. Presentation. Posters.
2.4	An exercise in probability	The company has asked you to explain how to express probabilities as percentages, fractions and decimals.	Booklet. Poster.
2.5	Finding a solution	The company now asks you to use the series, probability and recursion techniques that you demonstrated previously to solve some problems.	A set of mathematical tasks.
3.1, 3.2, 3.3, 3.4	Graph theory	The company now asks you to put together a beginner's guide to graph theory. The guide should describe the different types of graph and explain their characteristics. The guide should include a sections that: • describe how connected objects can be represented • describe the use of weighted graphs to solve problems.	Booklet. Posters.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC in IT sector suite. This unit has particular links with:

Level 1	Level 2	Level 3
	Mathematics for IT	Mathematics for IT Practitioners
	Data Representation and Manipulation for IT	

This unit maps to some of the underpinning knowledge from the following areas of competence in the Level 2 National Occupational Standards for IT (ProCom):

4.2 Data Analysis.

Essential resources

Learners will need access to a computer with a mathematical or spreadsheet package. A good range of case study examples and exercises should be provided.

Indicative reading for learners

Textbooks

Cameron P - *Introduction to Algebra – 2nd edition* (OUP Oxford, 2007) ISBN-10: 0198527934 ISBN-13: 978-0198527930

Johnston-Wilder S (Editor), Professor Mason J (Editor) – *Developing Thinking in Geometry* (Sage Publications Ltd, 2005) ISBN-10: 1412911699 ISBN-13: 978-1412911696

Lawler G – *Algebra: Basic Algebra Explained* (Studymates Ltd, 2005) ISBN-10: 1842850687 ISBN-13: 978-1842850688

Lawler G – *Understanding Maths: Basic Mathematics Explained – 3rd edition* (Aber Publishing, 2007) ISBN-10: 1842850865 ISBN-13: 978-1842850862

Websites

mathworld.wolfram.com

tutorial.math.lamar.edu

www.utm.edu/departments/math/graph

Functional Skills – Level 2

Skill	When learners are …
Mathematics - Representing	
Select a range of mathematics to find solutions	using series, probability and recursion techniques to solve some problems
Mathematics - Analysing	
Apply a range of mathematics to find solutions	demonstrating how matrices can be used to represent ordered data; performing add, subtract and scalar multiplication operations on a matrix; multiplying two matrices; finding the inverse and transpose of a matrix applying sequence and series, probability and recursion techniques to develop solutions to a range of problems
Mathematics - Interpreting	
Interpret and communicate solutions to multistage practical problems in familiar and unfamiliar contexts and situations	demonstrating how matrices can be used to represent ordered data; performing add, subtract and scalar multiplication operations on a matrix; multiplying two matrices; finding the inverse and transpose of a matrix applying sequence and series, probability and recursion techniques to develop solutions to a range of problems
Draw conclusions and provide mathematical justifications	demonstrating how matrices can be used to represent ordered data; performing add, subtract and scalar multiplication operations on a matrix; multiplying two matrices; finding the inverse and transpose of a matrix applying sequence and series, probability and recursion techniques to develop solutions to a range of problems.