Data Structures and Algorithms (DSALG)

Questions for you to answer:

1: What is a **Data Structure**?

2: What is an **Algorithm**?

What is the DSALG unit about?

This unit involves the study, implementation and applications of fundamental data structures. During this unit you will explore and analyse the use of data structures in problem solving and algorithm design. As an integral part of the course students are expected to implement and manipulate data structures in a programming language of their choice for the solution of problems.

What does the DSALG unit involve?

Learning about a variety of different types of **data structures** to enable you write efficient **algorithms** and hence developing **efficient** programs, as well as providing support for other units in levels 5 and 6.

During this unit you will:

- Study the implementation and applications of different types of data structures (linear, hierarchical and graphical);
- Explore and analyse the use of different types of data structures in algorithmic design;
- Design and write algorithms using different types of data structures for the solution of problems;
- Review the practical effects and the efficiency of the implementation choices of a selection of data structures in the design of algorithms.

What will you be expected to know in order to study the DSALG unit?

- Able to think logically and clearly;
- Able to write an algorithm for the solution of a problem
- Proficient in either a structured and/or an object-oriented programming language
  (eg: Studied either Level 4 INTPROG or an equivalent unit covering Python and/or Java);
- Be confident in elementary mathematics – algebra, logarithms, modulo arithmetic.

Note – in this unit:

- You will **not** be taught another new programming language;
- You will **not** be taught how to write program code.

What are the aims of the DSALG unit?

- To develop an in-depth understanding of data structures and to use these data structures efficiently in problem solving.
- To develop an understanding of the data structures required for efficient representation, organization, searching and manipulation of computer data.

What are the learning outcomes for the DSALG unit?

On successful completion of this unit, you should be able to:

- Construct and use fundamental data structures to solve problems in static and dynamic environments.
- Demonstrate the practical effects of different choices of data structures for solving problems.
- Critically review and analyse the practical effects of different implementation choices of data structures in the design of algorithms.

What will you study on the DSALG unit?

The topics covered in the unit include:

- Efficiency of algorithms: BigO notation.
- Recursion and Recursive Algorithms.
- Linear Data Structures:
  - Array, Linked lists, Skiplists, Heaps.
  - Applications: Stack ADT, Queue ADT, Priority queue ADT, Hash tables and hashing algorithms.
- Hierarchical Data Structures:
  - Binary trees; Binary search trees;
  - Basic algorithms including traversal algorithms;
  - Self-Balancing Binary Search Trees - AVL Trees;
  - Self-Organising Binary Trees - Splay trees.
  - Multi-Branch Search Trees - 2-3 Trees, B Trees, B*Trees, B+Trees;
  - Applications: Postfix and Prefix notation; Parse trees; Huffman Coding.
- Graph Data Structures:
  - Basic algorithms including traversal algorithms;
  - Algorithms: Topological sorting; Reachability (Warshall's Algorithm); Shortest path trees (Dijkstra's Algorithm); Spanning Trees (Prim's and Krustal's Algorithms).

How is the DSALG unit assessed?

The assessment strategy is to enable students to demonstrate an in-depth understanding and appreciation of the practical effects of data structures when applied to problem solving (all learning outcomes).

Mid–Course Assessment (In-Class Test) – 25%

- Time Allowed = 45 mins
- Structure of the In-Class Test:
  - Individual supervised in-class test consisting of 5 short answered and 20 multi-choice questions based on material covered in workshops 1 to 8. Closed book. Total 50 marks.
  - Completed during your tutorial.
  - Questions will enable you to demonstrate your understanding and appreciation data structures as covered in teaching block one.

Examination – 75%

- Time Allowed = 2 hours
- Structure of examination:
  - Answer 3 questions from 4 questions. Closed book. Each question worth 25 marks. Total 75 marks.
  - Questions will enable you to demonstrate your practical understanding of data structures.

Feedback from a previous DSALG student

Here is a message to you all from a placement student who studied DSALG in 2015/16:

"Since starting my placement I'm very glad I had taken the DSALG unit because it's really helped in a practical way:

- *Efficiency is one of the main things I've encountered so algorithm design and BigO help me to understand the concept of efficient coding and in practice understanding the importance of designing efficient algorithms or understanding why algorithms are written in a certain way.*
- *Similarly with data structures and the mechanism of storage, retrieval and management of the structure as well as the efficiency of the operations. It gives you an understanding and important ideas on working out which tool is right for the job and why."*

How is the unit delivered?

Lecturer & Tutor: Annette Wilson

- Delivered as a series of 17 workshops over 24 weeks (8 in TB1 and 9 inTB2)
- Each week - I hour lecture + 1 hour classroom based tutorial (over 24 teaching weeks). Plus supporting tutorial during CAP week 39/40 (see your own timetables)
- **Unit Materials:**
  - Two booklets consisting of the workshop notes and exercises will be provided.
    - Booklet 1 covers the first 8 workshops (TB1 - weeks 1-11)
    - Booklet 2 covers the remaining 9 workshops (TB2 - weeks 1-10).
  - Content of booklets is also available through Moodle.
  - Additional material provided via Moodle (including: additional supporting materials, answers to exercises and weekly quizzes in TB1).
- **Weekly Lecture**
  - The lecture will be a discussion of the current workshop
  - You will be expected to have reviewed the workshop material before the lecture.
  - You will be required to actively participate during each session.
  - Some lectures will start with a quick quiz on the current and/or previous workshops.
- **Weekly Tutorial** = your opportunity:
  - To discuss any issues or concerns arising from the current workshop;
  - To complete weekly exercises.
  - Note: Additional exercises and short formative tests will also be provided during some tutorials. Exercises and formative tests provide the basis for the unit assessments.

Some warnings about the DSALG unit:

1. This unit is **not** another programming unit – in this unit:
   - I will **not** be teaching you another programming language and
   - I will **not** be teaching you how to write program code

   But: I will expect you to be proficient in either a structured or an OO programming language.

   In this unit you will learn about various different types of **data structures** to enable you write efficient **algorithms** and thus write good efficient programs.
2. You will be expected to participate and engage in this unit throughout (ie from the start to the end) – students who disengage from this unit tend to fail the unit badly - often finding themselves repeating the unit – you have been warned!

Text Books (including the much cheaper E-Texts)

Below is a small selection of recommended textbooks covering *"Data Structures and Algorithms":*

1. N. Dale, D.T. Joyce, C. Weems, 2016, **Object-Oriented Data Structures using Java** (4th Edition)
   Jones & Bartlett Learning: Interactive eBook: ISBN 978-1-284-08920-2
   Jones & Bartlett Learning: Print (inc. Interactive eBook) 978-1-284-08909-7
2. M. Goodrich, R. Tamassia & M. Goldwasser, 2014, **Data Structures & Algorithms in Java** (6th Edition)
   Wiley E-Text: ISBN 978-1-118-80836-8 Wiley Print: ISBN 978-1-118-80857-3
3. M. Goodrich, R Tamassia, M. Goldwasser, 2013, **Data Structures and Algorithms in Python** (1st Edition)
   Wiley E-Text: ISBN 978-1-118-54958-2 Wiley Print: ISBN: 978-1-118-29027-9
4. M.Goodrich & R. Tamassia, 2015, **Algorithm Design and Applications** (1st Edition)
   Wiley E-Text: ISBN 978-1-119-02852-1 Wiley Print: ISBN 978-1-118-33591-8
5. E Koffman and Paul A T Wolfgang, 2016, **Data Structures, Abstraction & Design Using Java** (3rd Edition)
   Wiley E-Text: ISBN 978-1-119-18654-0 Wiley Print: ISBN 978-1-119-18652-6

Useful Web Resources:

- **Definitions**: http://www.nist.gov/dads/
- **UTube** – there are many useful U-tubes on all aspects of data structures available online.

Moodle site for DSALG

Within each workshop you will find:

1. **Lecture Notes**
   - Supporting notes and other supporting material for the workshop.
2. **Activities**
   - Activities are like exercises but within the unit notes for the workshop. These activities may be discussed during the lecture or you may be required to complete them outside the lecture and bring solutions to the tutorials for further discussion.
3. **Exercises**
   - You are expected to attempt the exercises as preparation for the tutorial.
   - Answers to exercises will be provided via Moodle.
4. **Quizzes**
   - Selection of multi-choice questions based on the workshop material.
   - Many questions are taken from previous examination papers.

Symbols used in the workshops and exercises

I use a number of symbols to draw your attention to various things as follows:

1. The following symbol is used when I have made a statement that I require you to think about.

2. I use the following symbol when I would expect you to fully understand what is being explained.

   If you don't – then I would expect you to be telling me.

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Note: My normal working days are Monday, Tuesday and Wednesday