Title (Units):	**COMP3005 Design and Analysis of Algorithms (3,3,0)**

Course Aims:	The primary objective of this course is to introduce the topics of algorithms as a precise mathematical concept, and study how to design algorithms and analyze their efficiency and memory needs. Also, the issue of problem complexity will be addressed. The course consists of a strong mathematical analysis component in addition to the design of various algorithms. By the end of the course, the successful student will be able to:

1. Understand, explain, model, and analyze a given problem as an algorithm.
2. Investigate whether the algorithm found is the most efficient.
3. Formulate the time order analysis for an algorithm.
4. Formulate the space needs for the implementation of an algorithm.
5. Identify the complexity of problems

Prerequisite:	COMP2015 Data Structures and Algorithms
	MATH1205 Discrete Mathematics

Course Intended Learning Outcomes (CILOs):
Upon successful completion of this course, students should be able to:

No.	Course Intended Learning Outcomes (CILOs)
	Knowledge
1	Explain the basic concepts of time and space complexity analysis of algorithms
2	Describe the techniques for designing efficient algorithms: divide-and-conquer, greedy and approximate algorithms, dynamic programming, amortized analysis, and computational geometry
3	Describe the advanced data structures of red-black tree, B-tree and van Emde Boas Trees
4	Identify the complexity of problems
	Professional Skill
5	Solve a problem using an algorithm
6	Formulate the time-complexity analysis for an algorithm

Calendar Description:	This course is to introduce the techniques of designing efficient algorithms including divide-and-conquer strategy, dynamic programming, greedy and approximate algorithms, and so forth, and the applications of these techniques to design non-trivial algorithms, e.g. advanced data structures, graph algorithms, sorting algorithms and computational geometry. The time and space complexity of algorithms will be analyzed from a theoretical point of view. Also, the issue of problem complexity will be addressed.

Teaching and Learning Activities (TLAs):

CILOs	Type of TLA
1 - 6	Students will learn concepts and skills on algorithm design and analysis in lectures. Tutorials will be conducted to provide more examples and exercises to students so that they have an in-depth understanding of the teaching materials.
2 - 6	Students will work on written assignments / programming assignment / in-class exercises, and examination to enhance their understanding of algorithm design and analysis

Assessment:

No.	Assessment Methods	Weighting	CILOs to be addressed	Description of Assessment Tasks
1	Assignments	30%	1-6	Continuous assessments in the forms of written assignments and programming assignment are designed to measure how well students have learned the basic concepts and skills of analyzing, designing and implementing an algorithm.

2	Midterm	10%	5-6	Midterm is designed to measure how well students master the skills of solving problems designing and analysing an algorithm.
3	Examination	60%	1-6	Final Examination questions are designed to evaluate how far students have achieved their intended learning outcomes. Questions will primarily be analysis and skills based to assess the student's ability in the analysis, design and realization of algorithms.

Assessment Rubrics:

Excellent (A)	• Achieve all CILOs, demonstrating a good mastery of both the theoretical and practical aspects of the knowledge and skills associated with algorithm design and analysis • Able to develop correct and efficient solutions to problems with the algorithm complexity analysis • Demonstrate a thorough understanding and solid knowledge of algorithm design and analysis concepts, and algorithm techniques • Able to apply a variety of algorithm techniques and relevant knowledge for solving new problems
Good (B)	• Achieve most of the six CILOs, demonstrating a good understanding of the knowledge and skills associated with algorithm design and analysis • Able to develop correct solutions to problems with the basic algorithm analysis • Demonstrate a competent level of knowledge of algorithm design and analysis • Ability to make use of appropriate techniques and knowledge and apply them to familiar problems
Satisfactory (C)	• Achieve some of the six CILOs, demonstrating a basic level of understanding of the knowledge and skills associated with algorithm design and analysis • Able to provide acceptable solutions to problems with the basic knowledge of algorithm complexity analysis • Demonstrate an adequate level of knowledge of algorithm design and analysis • Ability to make use of some techniques and knowledge and apply them to familiar situations
Marginal Pass (D)	• Achieve few of the six CILOs, with minimal understanding of the associated concepts and underlying methodologies • Able to provide solutions to simple problems • Demonstrate a basic level of knowledge of algorithm design and analysis • Ability to apply some techniques and knowledge to a limited number of typical situations
Fail (F)	• Achieve none of the six CILOs, with little understanding of the associated concepts and underlying methodologies • Unable to provide solutions to simple problems • Knowledge of algorithm design and analysis falling below the basic minimum level • Unable to apply techniques and knowledge to situations or problems

Course Content and CILOs Mapping:

Content		CILO No.
I	Introduction and Mathematical Foundations	1,2
II	Sorting Algorithms	1,2,5,6
III	Advanced Data Structures	3,5
IV	Algorithm Design and Analysis Techniques	1,2,5,6
V	NP-Completeness	1,4
VI	Computational Geometry	1,5
VII	Approximation Algorithms	1,5

References:
- Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest and Clifford Stein, Introduction to Algorithms, 4th Edition, The MIT Press, 2022.
- Mark Allen Weiss, Data Structures and Algorithm Analysis in C++, 4th Edition, Addison Wesley, 2013.
- Anany Levitin, Introduction to the Design and Analysis of Algorithms, 3rd Edition, Addison Wesley, 2011.
- R.C.T. Lee, S.S. Tseng, R.C. Chang and Y.T. Tsai, Introduction to the Design and Analysis of Algorithms --- A Strategic Approach, McGraw-Hill, 2012.
- Jon Kleinberg and Eva Tardos, Algorithm Design, Pearson, 2006.

Course Content:

Topic

I. Introduction and Mathematical Foundations
    A. Algorithms, analyzing and designing
    B. Growth of functions
    C. Recurrences
    D. Probabilistic analysis and randomized algorithms

II. Sorting Algorithms
    A. Quicksort
    B. Sorting in linear time
    C. Medians and order statistics

III. Advanced Data Structures
    A. Red-black trees
    B. Van emde boas trees
    C. Disjoint sets

IV. Algorithm Design and Analysis Techniques
    A. Dynamic programming
    B. Greedy algorithms
    C. Amortized analysis
    D. Divide-and-conquer

V. NP-Completeness
    A. Polynomial time
    B. Polynomial-time verification
    C. NP-completeness and reducibility
    D. NP-completeness proofs
    E. NP-complete problems

VI. Computational Geometry
    A. Line-segment properties
    B. Determining segments intersection
    C. Finding convex hull

VII. Approximation Algorithms
    A. The vertex-cover problem
    B. The traveling-salesman problem
    C. The set-covering problem