Title (Units): **COMP4065 Performance Modelling and Analysis of Computer Systems (3,2,1)**

Course Aims: This course provides students with basic knowledge and skills of performance modelling and analysis of computer systems. In particular, queueing systems, queueing networks, and computer simulations will be studied.

Prerequisite: MATH1005 Calculus
MATH2005 Probability and Statistics for Computer Science

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

No.	Course Intended Learning Outcomes (CILOs)
	Knowledge
1	Describe purpose of quantitative analysis
2	Explain the basic structure of a queueing system
3	Illustrate queueing systems with service discriminations and practical limitations
4	Explain basic concepts and features of queueing networks
5	Describe workload characterization and simulation models
	Professional Skill
6	Carry out quantitative analysis to computer systems

Calendar Description: This course provides students with basic knowledge and skills of performance modelling and analysis of computer systems. Topics to be covered include queueing systems, queueing networks, and computer simulations. In addition, some case studies will be introduced to help students acquire practical insights of this field.

Teaching and Learning Activities (TLAs):

CILOs	Type of TLA
1-6	Students will attend lectures to learn the principles of the topics covered. They will study some real cases which illustrate the principles and performance modelling and analysis of computer systems.
1-6	Students will work on written assignments to apply what they have learnt.

Assessment:

No.	Assessment Methods	Weighting	CILOs to be addressed	Description of Assessment Tasks
1	Continuous Assessment	30%	1-6	Continuous assessments are designed to measure how well students have learned the basic concepts in queueing theory and computer simulations.
2	Examination	70%	1-6	Final examination questions are designed to see how far students have achieved their intended learning outcomes. Questions will primarily be analysis and skills based to assess students' understanding of the topics and ability in performance modeling and analysis of computer systems.

Assessment Rubrics:

	Excellent (A)	Good (B)	Satisfactory (C)	Marginal Pass (D)	Fail (F)

Quantitative analysis	• Demonstrates thorough understanding of the purpose of quantitative analysis • Has a high degree of effectiveness and correctness in carrying out quantitative analysis to computer systems	• Demonstrates sufficient understanding of the purpose of quantitative analysis • Has a considerable degree of effectiveness and correctness in carrying out quantitative analysis to computer systems	• Demonstrates moderate understanding of the purpose of quantitative analysis • Has a moderate degree of effectiveness and correctness in carrying out quantitative analysis to computer systems	• Demonstrates some understanding of the purpose of quantitative analysis • Has some degree of effectiveness and correctness in carrying out quantitative analysis to computer systems	• Demonstrates limited understanding of the purpose of quantitative analysis • Has a limited degree of effectiveness and correctness in carrying out quantitative analysis to computer systems
Basic structure of queueing system	• Demonstrates thorough knowledge and understanding of the basic structure of queueing systems, Little's formula, and the Pollaczek-Khintchine formula	• Demonstrates sufficient knowledge and understanding of the basic structure of queueing systems, Little's formula, and the Pollaczek-Khintchine formula	• Demonstrates moderate knowledge and understanding of the basic structure of queueing systems, Little's formula, and the Pollaczek-Khintchine formula	• Demonstrates some knowledge and understanding of the basic structure of queueing systems, Little's formula, and the Pollaczek-Khintchine formula	• Demonstrates limited knowledge and understanding of the basic structure of queueing systems, Little's formula, and the Pollaczek-Khintchine formula
Queueing systems with service discriminations and practical limitations	• Demonstrates thorough knowledge and understanding of queueing systems with service discriminations and practical limitations	• Demonstrates sufficient knowledge and understanding of queueing systems with service discriminations and practical limitations	• Demonstrates moderate knowledge and understanding of queueing systems with service discriminations and practical limitations	• Demonstrates some knowledge and understanding of queueing systems with service discriminations and practical limitations	• Demonstrates limited knowledge and understanding of queueing systems with service discriminations and practical limitations
Queueing networks	• Demonstrates thorough knowledge and understanding of key concepts of queueing networks	• Demonstrates sufficient knowledge and understanding of key concepts of queueing networks	• Demonstrates moderate knowledge and understanding of key concepts of queueing networks	• Demonstrates some knowledge and understanding of key concepts of queueing networks	• Demonstrates limited knowledge and understanding of key concepts of queueing networks
Computer simulations	• Demonstrates thorough knowledge and understanding of workload	• Demonstrates sufficient knowledge and understanding of workload	• Demonstrates moderate knowledge and understanding of workload	• Demonstrates some knowledge and understanding of workload	• Demonstrates limited knowledge and understanding of workload

	characterization and simulation models	characterization and simulation models	characterization and simulation models	characterization and simulation models	characterization and simulation models

Course Content and CILOs Mapping:

Content		CILO No.
I	The Purpose of Quantitative Analysis	1
II	Basic Structure of a Queueing System and Fundamental Relationships	2,6
III	Systems With Service Discriminations and Practical Limitations	3,6
IV	Queueing Networks	4,6
V	Workload Characterization and Simulation Models	5,6
VI	Case studies	6

References:

- R. K. Jain, The Art of Computer Systems Performance Analysis: Techniques for Experimental Design, Measurement, Simulation, and Modeling, Wiley, 1991.
- Edward D. Lazowska, et. al., Quantitative System Performance, Computer System Analysis Using Queuing Network Models, Prentice Hall, 1984.
- C. H. C. Leung, Quantitative Analysis of Computer Systems, John Wiley & Sons, 1988.
- L. Kleinrock, Queueing Systems, Volume 1: Theory, Wiley-Interscience, 1975.
- A. Kumar, D. Manjunath, and J. Kuri, Communication Networking, an Analytical Approach, Morgan Kaufmann 2004.

Course Content:

Topic

I. The Purpose of Quantitative Analysis
   A. Analytic and simulation models
   B. Prediction and measurement
   C. Tuning and optimization

II. Basic Structure of a Queueing System and Fundamental Relationships
   A. Request arrival and service characteristics
   B. Work, traffic intensity, utilization, and throughput
   C. Little's formula
   D. The Pollaczek-Khintchine formula

III. Systems With Service Discriminations and Practical Limitations
   A. Non-preemptive and preemptive resume priority systems
   B. Shortest-Job-First and Round-Robin scheduling disciplines
   C. M/M/1 with limited buffer, finite population, loss system
   D. M/M/m and M/M/∞

IV. Queueing Networks
   A. The output of an M/M/m queue: Burke's theorem
   B. General exponential open queueing networks: Jackson's Theorem
   C. Closed queueing networks

V. Workload Characterization and Simulation Models
   A. Workload characterization
   B. Elements of simulation programming
   C. Analysis of simulation results

VI. Case studies
   A. Computer systems
   B. Database systems
   C. Data communication networks