Module 7 Operating System Design

Module title	Operating System Design
Module NFQ level (only if an NFQ level can be demonstrated)	n/a
Module number/reference	BSCH-OSD
Parent programme(s)	Bachelor of Science (Honours) in Computing Science
Stage of parent programme	Stage 1
Semester (semester1/semester2 if applicable)	Semester 2
Module credit units (FET/HET/ECTS)	ECTS
Module credit number of units	5
List the teaching and learning modes	Direct, Blended
Entry requirements (statement of knowledge, skill and competence)	Learners must have achieved programme entry requirements.
Pre-requisite module titles	None
Co-requisite module titles	None
Is this a capstone module? (Yes or No)	No
Specification of the qualifications (academic, pedagogical and professional/occupational) and experience required of staff (staff includes workplace personnel who are responsible for learners such as apprentices, trainees and learners in clinical placements)	Qualified to as least a Bachelor of Science (Honours) level in Computer Science or equivalent and with a Certificate in Training and Education (30 ECTS at level 9 on the NFQ) or equivalent.with a Certificate in Training and Education (30 ECTS at level 9 on the NFQ) or equivalent.
Maximum number of learners per centre (or instance of the module)	60
Duration of the module	One Academic Semester, 12 weeks teaching
Average (over the duration of the module) of the contact hours per week	3
Module-specific physical resources and support required per centre (or instance of the module)	One class room with capacity for 60 learners

Analysis of required learning effort		
	Minimum ratio teacher / learner	**Hours**
Effort while in contact with staff		
Classroom and demonstrations	1:60	24
Monitoring and small-group teaching	1:25	12
Other (specify)		
Independent Learning		
Directed e-learning		
Independent Learning		54
Other hours (worksheets and assignments)		35
Work-based learning – learning effort		
Total Effort		125

Allocation of marks (within the module)					
	Continuous assessment	**Supervised project**	**Proctored practical examination**	**Proctored written examination**	**Total**
Percentage contribution	50%			50%	100%

Module aims and objectives

This module focuses on the concepts involved in the design of an operating system; an understanding of its complexity and it's many requirements. It introduces the learner to some fundamental algorithms used in operating systems. It introduces the concept of concurrency in an OS; explores the concept of multiprocessing and recourse management strategies

Minimum intended module learning outcomes

On successful completion of this module, the learner will be able to:

1. Discuss the function of operating systems at a generic level
2. Describe the major components of an operating system and their functions
3. Explain how the operating system relates to the underlying hardware and the software that runs on it
4. Discuss security and protection related issues in operating systems
5. Critically analyse memory management, file management, device management, process, and processor management and present conclusions.

Rationale for inclusion of the module in the programme and its contribution to the overall MIPLOs

This module aims to introduce learners to Operating systems and provides them with understanding of major concepts and techniques evolved over time which shaped and influenced the development of Operating systems of today. Appendix 1 of the

programme document maps MIPLOs to the modules through which they are delivered.

Information provided to learners about the module

Learners receive a programme handbook to include module descriptor, module learning outcomes (MIMLO), class plan, assignment briefs, assessment strategy and reading materials.

Module content, organisation and structure

Introduction to operating systems

- Introduction: What is an Operating System;
- Types of OS: Batch, Time-Sharing, Personal Computer Systems, Parallel Systems, Distributed Systems;
- Operating System Structures: System Components, services, system calls, system programs, system structure.
- System design considerations;
- Introduction to DOS, Linux and another commercial desktop operating system; emerging and experimental operating systems to be used for practical work. Specialised environments and purpose-built OSs (e.g. embedded systems)

Processor management

- Definition of a process; process control block and process image; process states and life cycle.
- I/O bound jobs and CPU bound jobs
- Turnaround time, waiting time, execution time.
- CPU Scheduling: basic concepts and scheduling criteria.
- Scheduling algorithms: FCFS, Shortest job first, Priority, Shortest remaining, round robin

Process management

- Threads - overview and benefits; user and kernel threads.
- Processes: Process concept, operations on processes, cooperating processes, inter-process communication;
- Deadlocks: deadlock characterization, detection, methods for handling deadlocks, recovery from deadlock, deadlock prevention and avoidance.
- Synchronization: critical section problem, Two task solution, synchronization in hardware, Semaphores, classical synchronization problems.

Memory management

- Memory management: fixed, dynamic and reloadable partitions memory management systems. Contiguous memory allocation, paging and segmentation. Memory fragmentation.
- Virtual memory: demand paging, page wrapping, allocation of frames, thrashing.

- Contiguous Memory Allocation
- Page strategies: FIFO, Most recently used, least recently used. Optimal page replacement
- Security aspect of memory management

File management

- File Systems: File concept, access methods, Directory structure, protection, file system structure, allocation methods, free space management, Directory implementation, efficiency and performance.
- Fixed and variable record files, contiguous files. Sequential, Direct and indexed access files.

Device management

- Dedicated and shared devices.
- Sequential and Direct storage media devices. Inter record gap, Inter-block gap, Platers, cylinders, tracks and sectors.
- Fragmentation, Addressing on a disk.
- Calculating capacity and speed.
- Blocking and buffering.
- Seek, search and transfer times.
- Seek policies and seek strategies, and their comparison

Protection and security

- Protection and security considerations; goals and domain of protection; the security problem; threats, threats monitoring, and addressing

Module teaching and learning (including formative assessment) strategy

The module is taught as a combination of lectures and lab sessions. The lecture sessions discuss and explain to learners the theoretical underpinnings of how an operating system works. The tutorial lab sessions give learners an opportunity to interact the concepts on a more practical level.

Assessment is divided into three elements. First there are a number of tutorials that assess the learner's competency in specific topics on a weekly basis. There is a mid-semester class test. Finally, there is an end of semester exam that tests the learners understanding of the theoretical material.

Timetabling, learner effort and credit
The module is timetabled as one 2-hour lectures and one 1-hour labs per week.

The number of 5 ECTS credits assigned to this module is our assessment of the amount of learner effort required. Continuous assessment spreads the learner effort across the content.

There are 36 contact hours made up of 12 lectures delivered over 12 weeks with classes taking place in a classroom. There are also 12 lab sessions delivered over 12 weeks taking place in a fully equipped computer lab. The learner will need 49 hours of independent effort to further develop the skills and knowledge gained through the contact hours. An additional 40 hours are set aside for learners to work on worksheets and assignments that must be completed for the module.

The team believes that 125 hours of learner effort are required by learners to achieve the MIMLOs and justify the award of 5 ECTS credits at this stage of the programme.

Work-based learning and practice-placement
There is no work based learning or practice placement involved in the module.

E-learning
The college VLE is used to disseminate notes, advice, and online resources to support the learners. The learners are also given access to Lynda.com as a resource for reference.

Module physical resource requirements
Requirements are for a classroom for 60 learners equipped with a projector, and a space to allow the facilitation of group work through movable furniture.

Reading lists and other information resources
Recommended Text
Stallings, W. (2018) *Operating Systems: Internals and Design Principles*. New Jersey: Pearson.

Secondary reading
Tanenbaum, A. S. and Bos, H. (2015) *Modern Operating Systems*. Boston: Pearson.

Silberschatz, A., Galvin, P. B. and Gagne, G. (2010) *Operating System Concepts with Java*. Hoboken: John Wiley & Sons.

Holcombe, J. and Holcombe, C. (2017) *Survey of Operating Systems*. New York: McGraw-Hill Education.

Sobell, M. G. and Helmke, M. (2018) *A Practical Guide to Linux Commands, Editors, and Shell Programming.* Upper Saddle River: Prentice Hall

Specifications for module staffing requirements

For each instance of the module, one lecturer qualified to at least Bachelor of Science (Honours) in Computer Science or equivalent, and with a Certificate in Training and Education (30 ECTS at level 9 on the NFQ) or equivalent.with a Certificate in Training and Education (30 ECTS at level 9 on the NFQ) or equivalent.. Industry experience would be a benefit but is not a requirement.

Learners also benefit from the support of the programme Director, programme administrator, learner representative and the Student Union and Counselling Service.

Module Assessment Strategy

The assignments constitute the overall grade achieved, and are based on each individual learner's work. The continuous assessments provide for ongoing feedback to the learner and relates to the module curriculum.

No.	Description	MIMLOs	Weighting
1	Tutorials: aims at enhancing the understanding of module material covered.	1-5	25%
3	A mid-term test.	1-5	25%
4	Written exam that tests the theoretical aspects of the module	1-5	50%

All repeat work is capped at 40%.

Sample assessment materials

Note: All assignment briefs are subject to change in order to maintain current content.

Tutorial 1 – Introduction

Answer the following questions:

Q1) What are the differences between Interactive and Real time systems?

Q2) What is the difference between main memory and auxiliary memory?

Q3) Explain each of the following:

a) Multi-user operating system
b) Multiprocessing operating system
c) Multitasking operating system
d) Multithreading operating system
e) Distributed processing

Q4) What is a thread?

Q5) Describe micro computers and mini computers and outline the differences between them.

Q6) Explain the functions of Bounds, address and instruction registers.

Q7) With the aid of a diagram, describe the mechanism through which a user process transitions from user mode to kernel mode. What is this mechanism called?

Q8) Explain how to join two blocks in dynamic partitioning memory management system. Suggest a table of free partitions and show how to combine two partitions located in memory when deallocating memory in. give addresses and sizes of partitions.

Tutorial 2 – Memory & Process Management

1. Describe how internal fragmentation and external fragmentation can happen in Dynamic contiguous memory allocation systems.

2. A program requests pages in the following order:

   d c b a d c e d c b a e

   Construct a **page trace analysis** indicating page faults with an asterisk (*) using **Least Recently Used** (LRU) where:

   (i) Memory is divided into 3 page frames;

   (ii) Memory is divided into 4 page frames.

3. Computers use **paged memory.**

   (i) Briefly explain what is meant by paged memory.

   (ii) Give **two** advantages of paged memory.

4. Explain the following terms:

   (i) Thrashing;

   (ii) Most recently used page.

   (iii) The working set of pages in demand paging

   (iv) Memory deallocation in dynamic partitioning memory.

   (v) Page modified bit.

5. With reference to the 5 state ""process state diagram".

   i. Draw and label the 5 state "process state diagram".
   ii. Briefly describe all transitions within the diagram.

6. Discuss how the following pairs of scheduling criteria conflict in certain settings.

   - CPU utilization and response time
   - Average turnaround time and maximum waiting time
   - I/O device utilization and CPU utilization

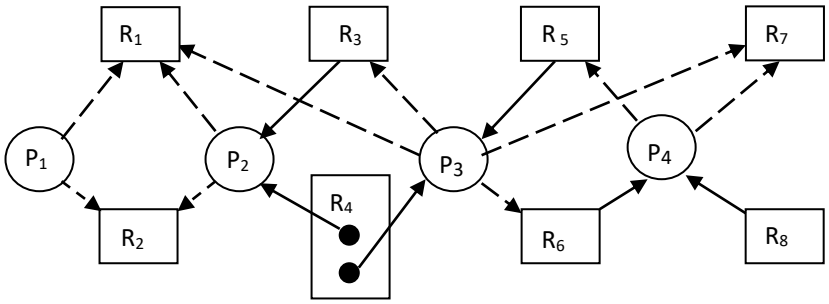
Tutorial 3 – Deadlocks

(1) Describe in detail how deadlocks can be avoided in a system.

(2) Suppose the current system resource allocation is described by the following table. A request is received by job 1 for 2 resources. Determine whether or not the request should be served in order to avoid a deadlock. Explain how the decision was reached.

Job No.	Devices Allocated	Maximum Required	Remaining Needs
1	0	4	4
2	3	5	2
3	4	8	4
Total number of devices allocated: 7			
Total number of devices in system: 10			

(3) Explain the deadlock detection algorithm using Directed resource graphs. Implement the algorithm on the Directed resource graph below and determine the deadlocked processes if any.



(4) Name and explain one method in which synchronisation can be achieved between processes.

(5) Describe the operation of Semaphores.

Tutorial 4 – Device & File management

Q1) Explain the differences between: access time and seek time.

Q2) A system has a disk with 200 tracks. The following I/O disk requests were received and are to be serviced:

98, 183, 37, 122, 14, 124, 65, 67.

The read and write head is located at track 53.
Which of the following schedule algorithms gives best performance?
FCFS, Shortest Seek Time First (SSTF), Scan, C-Scan, C-Look.
Draw a diagram showing the head movement across the tracks for each algorithm.

Q3) What are the advantages and disadvantages of a large block size for disk storage systems?

Q4) What is the difference between a dedicated device, a shared device and a virtual device? Give an example of each device.

Q5) Write four responsibilities of file manger?

Q6) With reference to tapes, what is the Inter record gap and what is its function?

Q7) In the case of sequential access contiguous file organisations, describe how records are accessed from files in both fixed and variable size record.

Class Test

OPERATING SYSTEMS DESIGN

This is a 60 minute test

ALL QUESTIONS TO BE ATTEMPTED.

(1) a) Explain the differences between user mode and kernel mode.

(5 marks)

b) Describe batch processing operating systems and outline its characteristics.

(5 marks)

(2) Identify and describe five events that would cause a process to lose its allocation of the processor.

(10 marks)

(3) Describe, with the aid of a diagram, the demand paged memory allocation scheme.

(10 marks)

(4) A program requests pages in the following order:

A D B B C A B D E C A E

Construct a **page trace analysis** indicating page faults with an asterisk (*****) using the **Most Recently Used (MRU)** policy where 3 page frames were allocated to the program in main memory.

(15 marks)

(5) Describe the idea of a semaphore including the P & V operations.

(15 marks)

GRIFFITH COLLEGE DUBLIN

QUALITY AND QUALIFICATIONS IRELAND
EXAMINATION

SAMPLE PAPER

OPERATING SYSTEMS DESIGN

Lecturer(s):

External Examiner(s):

Date: XXXXXXXX **Time:** XXXXXXX

THIS PAPER CONSISTS OF FOUR QUESTIONS
THREE QUESTIONS TO BE ATTEMPTED
SECTION A - COMPULSORY
SECTION B - TWO QUESTIONS TO BE ATTEMPTED

SECTION A – Compulsory

QUESTION 1

(a) What is a process control block? What information can it hold?

(10 marks)

(b) There are three major methods of organising and storing files: sequential file organisation, Direct file organisation and indexed file organisation. Discuss the characteristics of each of the methods. Illustrate how records are sorted in each method.

(10 marks)

(c) In demand paging, a process requests pages in the following order: a b c d b a c a b d e a c.

Construct a page trace analysis indicating page faults with an asterisk (*) using Least Recently Used (LRU) where memory is divided into three page frames.

(10 marks)

(d) In demand paging, explain how the memory manager will know which page was the most recently used page.

(10 marks)

(e) What is the difference between a track and a cylinder in a hard disk storage device?

(5 marks)

(f) With reference to tapes, what is the Inter record gap and what is its function?

(5 marks)

Total (50 marks)

SECTION B – Two questions to be attempted

QUESTION 2

(a) Explain what is meant by the Critical Section in process synchronisation software.

(5 marks)

(b) Using an example, explain how a binary semaphore can be used to control access to a critical section. Your answer should describe in detail the operations associated with a semaphore.

(10 marks)

(c) What values are kept in the bounds register and the relocation register in memory allocation systems? Explain the purpose of each of these two registers.

(10 marks)

Total (25 marks)

QUESTION 3

(a) With the aid of a diagram, explain the difference between a Page and a Page Frame.

(4 marks)

(b) Describe the role of a Page Map Table (PMT) in Demand Paged Virtual Memory allocation systems. Using a diagram, explain the key information it holds.

(8 marks)

(c) What is non-preemption in resource allocation? Explain how allocating a resource in a non-preemptive way can lead to deadlock.

(5 marks)

(d) With reference to deadlocks:

(i) List four methods for recovering from a deadlock.

(4 marks)

(ii) Outline four factors that should be considered when selecting a victim process in order to recover from a deadlock.

(4 marks)

Total (25 marks)

QUESTION 4

(a) Write five differences between Batch processing and Real Time processing Systems.

(5 marks)

(b) What advantage and disadvantage does having larger page size have in paged memory systems?

(5 marks)

(c) What is thrashing and how does it occur, explain how it affects the system.

(5 marks)

(d) Describe round robin process scheduling. What is the parameter associated with the scheduler? What is the issue in choosing a value for the parameter?

(5 marks)

(e) What are the different objectives or principles which must be considered while developing or selecting a scheduling algorithm?

(5 marks)

Total (25 marks)