Family Name _____

First Name _____

Student Number |__|__|__|__|__|__|__|__|

Venue _____

Seat Number _____

UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

No electronic/communication devices are permitted.

No exam materials may be removed from the exam room.

Computer Science and Software Engineering

EXAMINATION

End-of-year Examinations, 2018

ENCE360-18S2 (C) Operating Systems

Examination Duration: 120 minutes

Exam Conditions:

- Restricted Book exam: Approved materials only.
- No calculators are permitted

Materials Permitted in the Exam Venue:

- Students may bring in one A4 sheet of paper. Both sides may be used but it must be HAND WRITTEN. Not typed or photocopied notes.

Materials to be Supplied to Students (if needed)**:**

- 1 x Write-on question paper/answer book
- Extra sheets of write-on question paper (or answer book)
- String to tie exam materials together.

Instructions to Students:

- **Write your name and student ID above**
- This exam is worth a total of 100 marks
- Contribution to final grade: 50%
- Length: 12 questions
- Answer all questions.
- Check carefully the number of marks allocated to each question. This suggests the degree of detail required in each answer and therefore amount of time to spend on it.
- The amount of space provided also indicates the amount of detail expected.
- **Write strictly in the spaces allocated to each answer**. Do not write close to the margins, as the answer books will be scanned, and writing very close to the margin may not be picked up. If you require extra room, there is a blank page at the end of this booklet. You may also use additional sheets of paper; these must be fastened securely to your answer booklet. You should clearly indicate in the appropriate space that the answer is continued/provided elsewhere.

For Examiner Use Only

Question	Mark

Total _____

Questions Start on Page 3

Question 1 [6 marks] *Threads and Processes*

Using the code below in your discussion, describe the differences between creating a thread and creating a process and differences between running a thread and running a process. (Hint: About 12 facts for full marks.).

```
void main (void)
{
        pid_t childId = fork();
        if (childId == 0)
                printf("I am Tweedledee\n");
        else    printf("I am Tweedledum\n");
}
```

```
void* myFunction (void* arg)   {   printf("I am Tweedledum\n");    }

void main (void)
{
        pthread_t  childId;
        pthread_create (&childId, NULL, myFunction, NULL);
        printf("I am Tweedledee\n");
}
```

Question 2 [8 marks] *Scheduling*

The Banker's algorithm is a resource allocation & deadlock avoidance algorithm developed by Edsger Dijkstra.

Given the following processes and resources, use the banker's algorithm to enable all processes to run to completion without deadlock. Show your working.

- For the resources [CD drives, printers (no spooler), scanners, DVD drives],
  the total existing resources = [4 2 3 1]

- For the processes A, B and C:
  - Current allocations matrix (resources currently assigned to each process):
    - A = [0 0 1 0]
    - B = [2 0 0 1]
    - C = [0 1 2 0]
  - Request matix (resources still needed by each process to run to completion):
    - A = [2 0 0 1]
    - B = [1 0 1 0]
    - C = [2 1 0 0]

Question 3 [6 marks total**]** *Performance Optimisation*

Explain what each of the following mean, and give *one example for each* regarding how they are taken advantage of in a modern operating system:

(a) Delegation (of processing) **[2 marks]**

(b) Locality of reference **[2 marks]**

(c) Snoopy caching **[2 marks]**

Question 4 [6 marks] *Signals*

Signals provide a very basic communication technique between processes.

Describe signals, their purpose and limitations.

Question 5 [6 marks] *Caches*

Name and describe three write policies associated with caching.

Question 6 [6 marks] *Files*

Using diagrams, name and describe three disk arm scheduling algorithms.

Question 7 [12 marks] *Threads and semaphores*

The "**Sleeping Barber Problem**" describes an **inter-process communication and synchronization problem between multiple threads**. *This problem is analogous to that of keeping barbers working when there are customers, resting when there are none and doing so in an orderly manner. The barbers and their customers represent threads. This barber shop has barbers, barber chairs, and a number of chairs for waiting customers. When there are no customers, barbers sit in their chairs and sleep. As soon as a customer arrives, he either awakens a barber or, if all barbers are cutting hair, sits down in one of the vacant chairs. If all of the chairs are occupied, the newly arrived customer simply leaves. The challenge is to program the barber and the customers without getting into race conditions.*

Describe how this "Sleeping Barber Problem" is solved in terms of semaphores and threads.

Question 7 contd.

Question 8 [14 marks total] *Caches*

The following is a fragment of a 16KByte, 2-way associative L1 cache with a line size of 16 bytes, an update policy of write- deferred, write-allocate, and a replacement policy of least-recently-used (LRU).

Line	Tag	Valid?	Dirty?	Tag	Valid?	Dirty?
47	101	Y	N	111	N	N
46	010	Y	N	110	Y	Y
45	011	Y	Y	000	N	N
44	111	Y	Y	101	Y	N
43	010	Y	N	111	Y	N

For each of the following memory operations (in binary) for a 64KByte virtual memory space, indicate the number of memory transfers assuming that the bus width is 4 bytes, and show the state of the "valid" and "dirty" bits of the corresponding cache entry after the operation.

Show your working. **[4 marks]**

(a) READ: 0100001011011010 **[2 marks]**

(b) READ: 1100001011100111 **[2 marks]**

(c) WRITE: 1010001011110100 **[2 marks]**

(d) READ: 1100001011110000 **[2 marks]**

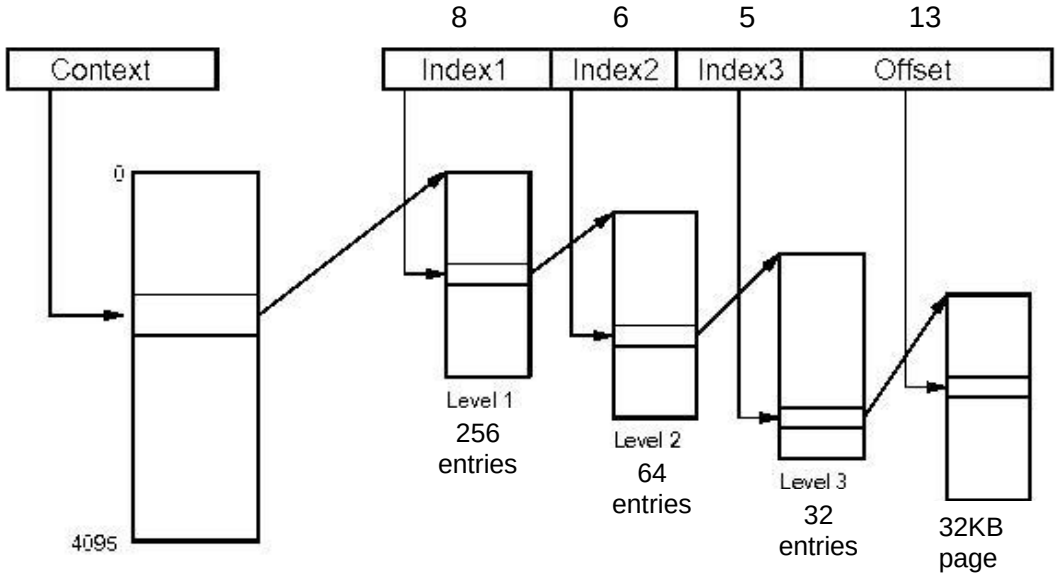
(e) WRITE: 0000001011111111 **[2 marks]**

Question 8 contd.

Question 8 contd.

Question 9 [12 marks] *Virtual memory*

A 32-bit architecture uses a 3-level page table as illustrated below.



Calculate how many bytes are required for the page table of a process on a system with a 4MB text segment, a 140MB data segment, and a 70MB stack.

Assume that:

- the text segment starts at 0x0,
- the data segment follows the text segment,
- the stack grows down from 0XFFFFFFFF.

Level 1 nodes are 8KB each, level 2 are 1KB each and level 3 nodes are 1KB each.

Hint 32 x 32KB = 1MB

Show your working.

Question 9 contd.

Question 10 [6 marks] *Virtualisation*

The first, second and third generations of virtualization were “full virtualisation”, “paravirtualization” and “hardware assisted virtualization”. Briefly describe one pro and one con for each of these three generations of virtualization.

Question 11 [12 marks total] *Caches lab*

You are implementing a very large simulation which can be easily broken down into many parallel tasks (e.g. an N-body physical gravity simulation).

(a) When implementing loop blocking for matrix-matrix multiplication, explain how you would you optimize memory access on an unknown CPU with unknown cache size(s). **[6 marks]**

(b) Explain in which priority order you would apply the following optimisations and why. **[6 marks]**

A. Use multi-threading or SIMD to compute many operations in parallel
B. Re-write the code in assembler to use the minimum number of instructions
C. Use loop blocking and optimise memory accesses

Question 12 [6 marks total] *Distributed Processing Lab*

In lab 6 you analysed the performance of a method to compute the length (l2 norm) of a vector using MPI_Scatter and MPI_Gather.

(a) How many local/remote processes would you use to run this method to get the best performance on two 4-core PCs? **[2 marks]**

(b) Name the two important factors that would change this and explain why. **[4 marks]**

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If you use this page, please refer to it from the original question.

End of Examination