UC
UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

End-of-Year Examinations 2015

Prescription Numbers: **ENCE360**

Paper Title: ***Operating Systems***

Time allowed: 2 hours

Number of pages: 6

- This exam is worth a total of 100 marks.
- Contribution to final grade: 60%.
- Length: 13 questions.
- Calculators are not allowed.
- Use the separate *Answer Booklet* for answering *all* questions.
- *This is a closed book test.*
  But you can have 2 sides of an A4 page of *handwritten* notes.
- Please answer *all* questions carefully and to the point. Check carefully the number of marks allocated to each question. The number of marks suggests the degree of detail required in each answer and the amount of time you should spend on the question.

Question 1 [6 marks total]

Discuss the following multi-tasking problems and solutions, if any.

(a) Busy waiting [2 marks]
(b) Starvation [2 marks]
(c) Race condition [2 marks]

Question 2 [6 marks]

Describe the difference between a mutex and semaphore.

Question 3 [6 marks]

Signals provide a very basic communication technique between processes. Describe signals, their purpose and limitations.

Question 4 [6 marks]

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

Question 5 [6 marks total]

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 6 [8 marks total]

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

(a) [2 marks] What are some practical problems with this algorithm?
(b) [6 marks] Given the following processes (P1,P2,P3) and resources (A,B,C,D), use the banker's algorithm to enable all processes to run to completion without deadlock. Show your working.

```
    Currently available resources:
     A B C D
Free 3 1 0 2
    Currently allocated resources:
     A B C D
P1   1 2 2 1
P2   1 0 3 3
P3   1 1 2 0
    Resources needed by each process to complete:
     A B C D
P1   3 3 2 2
P2   1 2 3 4
P3   1 1 5 0
```

Question 7 [6 marks]

Name and describe three write policies associated with caching.

Question 8 [8 marks]

Describe the differences between unnamed pipes and named pipes using the code below.

unnamed pipe:

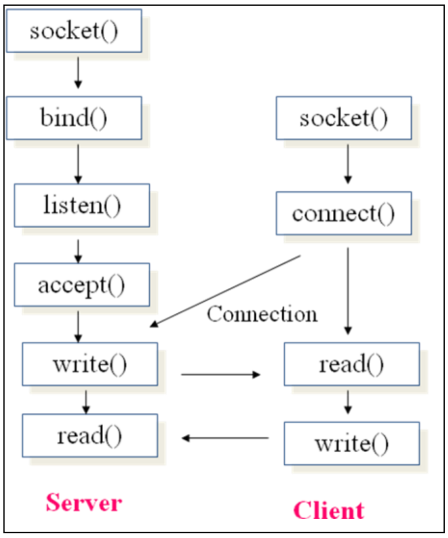
```
// create and open an unnamed pipe:
int pid[2];
pipe(pid);

write(pid[1], buffer, strlen(buffer));
read(pid[0], buffer, BUFSIZE);
```

named pipe:

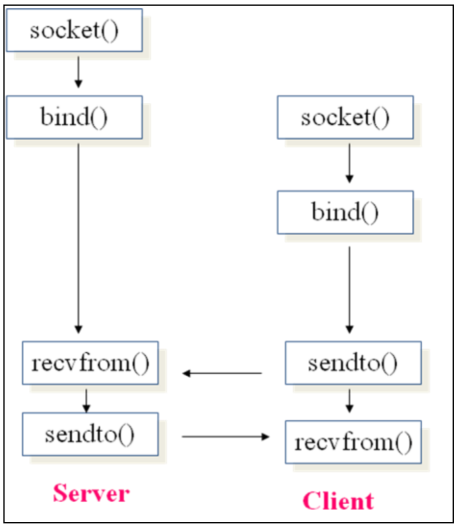
```
// create and open a named pipe:
int pid0, pid1;
mknod("./named_pipe_filename", S_IFIFO | 0666, 0);
pid1 = open("./named_pipe_filename", O_WRONLY);
pid0 = open("./named_pipe_filename", O_RDONLY);

write(pid1, buffer, strlen(buffer));
read(pid0, buffer, BUFSIZE);
```

Question 9 [8 marks]

Describe the differences between stream sockets and datagram sockets using the following diagrams (i) and (ii).



(i)



(ii)

Question 10 [10 marks total]

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 optimize memory access on an unknown CPU with unknown cache size(s). [4 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

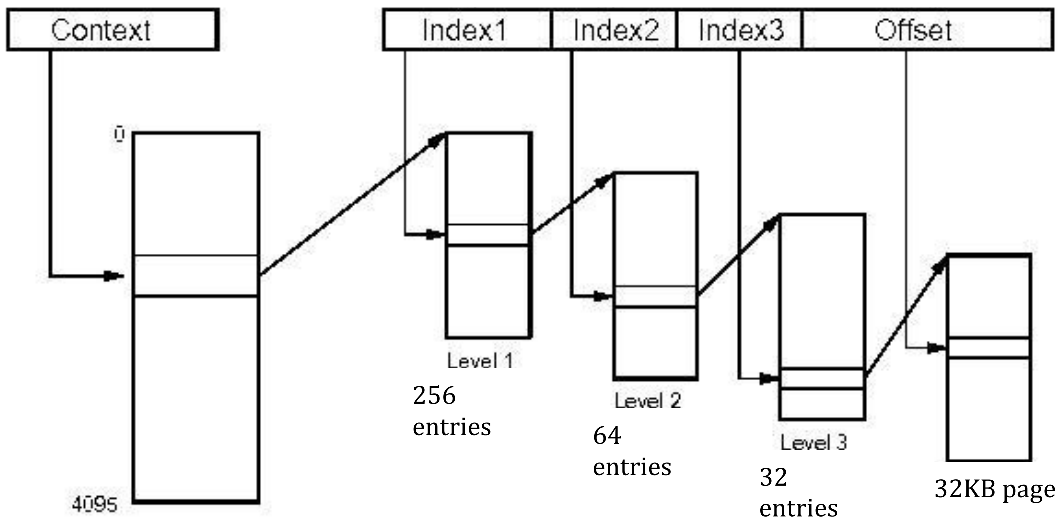
Question 11 [6 Marks total]

(a) Describe a key difference between code running in user mode and code running kernel mode [3 Marks]

(b) Describe the purpose of a translation lookaside buffer (TLB) [3 Marks]

Question 12 [12 marks]

A 32-bit RISC 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 SPARC system with a 40MByte text segment, a 40MByte data segment, and a 40MByte 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 2048 bytes each, level 2 are 512 bytes each and level 3 nodes are 256 bytes each.

Show your working.

Question 13 [12 marks total]

The following is a fragment of a 16KByte, 2-way associative L1 cache with a set (line) size of 32 bytes, an update policy of write-deferred, write-allocate, and a replacement policy of least-recently-used (LRU).

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

Consider the following five memory operations (in binary) for a 64KByte virtual memory space,
Note: [2 marks] to calculate the number of bits in the tag, set number and offset.

(a) [2 marks] `READ:  1100010110000000`

(b) [2 marks] `WRITE: 1010010110000100`

(c) [2 marks] `READ:  0100010110101010`

(d) [2 marks] `WRITE: 0000010110001111`

(e) [2 marks] `READ:  1100010111000111`

For each:

- indicate the number of memory transfers assuming that the bus width is 4 bytes,
- show the state of the "valid" and "dirty" bits of the corresponding cache entry after the operation.

Show all your working.

END OF PAPER