University of Colombo, Sri Lanka

UCSC *University of Colombo School of Computing*

Bachelor of Science in Computer Science

Academic Year 2017-2018 — Second Year Examination — Semester II

SCS2106 — Operating Systems I

(2 Hours)

Answer All Questions

Number of Pages = 12 Number of Questions = 4

To be completed by the candidate								
Index Number								

Important Instructions

- The duration of the paper is **2** Hours.
- The medium of instructions and questions is English.
- This paper has **4** questions on **12** pages.
- Answer **all** the **4** questions.
- **Write your answers on and only on the space provided** on this question paper.
- Do not tear off any part of this answer book. Under no circumstances may this book (or any part of this book), used or unused, be removed from the Examination Hall by a candidate.
- Questions appear on both sides of the paper. If a page is not printed, please inform the supervisor immediately.
- Any electronic device capable of storing and retrieving text, including electronic dictionaries and mobile phones, are **not allowed**.
- Non-programmable Calculators may be used.

To be completed by the examiners

1	
2	
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1. (a). The following, incomplete, code segment is written in the assembly instructions of the virtual machine used for the assignments of the SCS2106 course.

```
0 movv sp 80
1 movv a 100
2 movv b 400
3 call 20
4 add a b
5 out acc
6 halt

20 push a
21
22
23 movv a 20
24 movv b 80
25 add a b
26 out acc
27 pop acc
28 pop b
29 pop a
30 ret
```

i. What is the assembly instruction that should be in the memory location 21?

[3 marks]

ii. What is the assembly instruction that should be in the memory location 22?

[3 marks]

iii. Assume that the completed program has executed on the virtual machine. What is the output?

[3 marks]

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iv. What is the content of the memory at address 81 right after the instruction at the memory address 3 is executed? Justify your answer.

[5 marks]

(b). Assume that a process transits between the following states: *new*, *ready*, *running*, *waiting* and *terminated*. A process goes through the following state transitions.

$$X \rightarrow Y \rightarrow X \rightarrow Y \rightarrow X \rightarrow Y \rightarrow X \rightarrow Z \rightarrow Y$$

The states X, Y and Z are different states.

i. What is X?

[2 marks]

ii. What is Y?

[2 marks]

iii. What is Z?

[2 marks]

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(c). Following program is compiled and executed on an $x86$ machine.

```
#include <stdio.h>
#include <stdlib.h>

int main()
{

        int *p,*q;
        char *c;
        p=(int *)malloc(sizeof(int));
        q=p;
        c=(char *)p;
        free(p);
        *q=123;
        printf(" %d\n", *p);
        printf(" %d\n", c[1]);
}
```

i. What is the output of the first *printf*?

[2 marks]

ii. What is the output of the second *printf*?

[3 marks]

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2. (a). i. How many X's are printed by the following program?

```
int main()
{
  int x;
  for(x=0; x<3; x++)
    fork();
  printf("X\n");
  return 0;
}
```

[4 marks]

ii. Give the number of 0's, number of 1's and the number of 2's printed by the following program?

```
int main()
{
  int x;
  for(x=0; x<3; x++)
  {
     fork();
     printf("%d\n", x);
  }
  return 0;
}
```

[6 marks]

iii. What is the output of the following program?

```
int main()
{
     printf("%d \n", !fork());
     return 0;
}
```

[4 marks]

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(b). A solution to the mutual exclusion problem that uses `TestAndSet()` is given bellow. This code is given with respect to the process `i`.

```
do{
 waiting[i] = X;
 key = Y;
 while(waiting[i] && key)
   Z = TestAndSet(&lock);
 waiting[i] = FALSE;

   // critical section

 j = (i + 1) % n;
 while ((j != i) && !waiting[j])
    j = (j+1) % n;

 if (j == R)
    lock = FALSE;
 else
    waiting[j] = FALSE;

   // remainder section

 } while (TRUE);
```

i. What is `X`?

[2 marks]

ii. What is `Y`?

[2 marks]

iii. What is `Z`?

[2 marks]

iv. What is R?

[2 marks]

v. A solution to a critical section problem must satisfy three requirements. List the requirements that the above solution satisfies.

[3 marks]

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3. (a). A system uses 24 bits addresses and the memory is byte addressable. The page size used in this system is 4096 bytes and the system uses a single level page table.

i. What is the frame size suitable for this system?

[2 marks]

ii. What is the size of the virtual address space?

[2 marks]

iii. How many pages are there in the virtual address space?

[2 marks]

iv. How many entries should be in the page table?

[2 marks]

(b). What are the four necessary conditions for a deadlock?

[4 marks]

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(c). A System has 12 instances of the resource type R and three processes, P_0, P_1, P_2, P_3, that require R. The maximum requirements of R for each process and the current allocations at time t_0 are given in the following table.

	Maximum Need	Current Allocation
P_0	9	5
P_1	9	2
P_2	4	2
P_3	11	0

i. The system is in a safe state at t_0. Give a safe sequence.

[4 marks]

ii. Assume that the maximum number of instances of the resource R that can be allocated to process P_3, while still keeping the systems at a safe state, is m. At time t_1 ($t_1 > t_0$) the process P_3 is granted m number of resources. Give the value of m and a safe sequence at t_1.

[4 marks]

iii. Assume that at time t_2 ($t_2 > t_1$), an instance of R, that is not allocated to any process, fails and taken out of the system. Is the system in a safe state at t_2 under this assumption? If it is in a safe state give a safe sequence. Otherwise justify your answer.

[5 marks]

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4. (a). Consider a UNIX UFS File system represented by inodes. Assume that this system uses 32 bit addresses (block pointers) and a block size of 4096 bytes. Assume that there are 12 direct blocks and three levels of indirection through 13th to 15th indices in the inode.

What is the maximum size of a file (in KB, MB, or GB) that can be stored with the following:

i. Using direct blocks only:

[2 marks]

ii. With direct and single level of indirection:

[2 marks]

iii. With direct, single indirection and double indirection:

[4 marks]

iv. With direct, single indirection, double indirection, and triple indirection:

[4 marks]

(b). Assume that you are given all the information stored in an i-node of a file in a UFS file system. Is it possible to find the name of the file using only this information? Explain your answer.

[3 marks]

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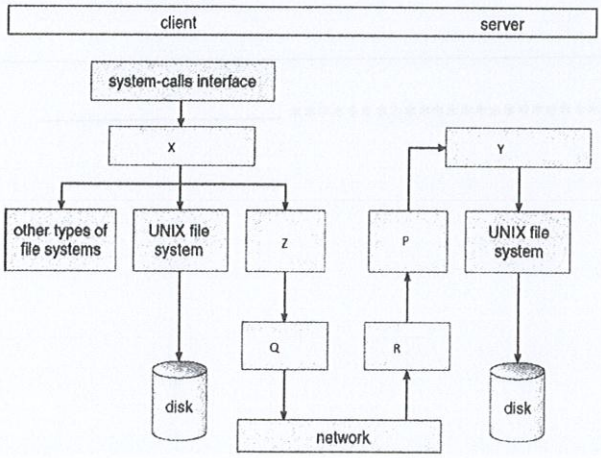
(c). List the four (4) key object types stored in Virtual File System (VFS) in Linux.

[4 marks]

(d). Consider the following diagram depicting the NFS file system.



i. What is X?

[1 marks]

ii. What is Y?

[1 marks]

iii. What is Z?

[1 marks]

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iv. What is P?

[1 marks]

v. What is Q?

[1 marks]

vi. What is R?

[1 marks]

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