UNIVERSITY OF LONDON

BSc EXAMINATION 2017

For Internal Students of
Royal Holloway

DO NOT TURN OVER UNTIL TOLD TO BEGIN

CS2850: Operating Systems

Time Allowed: **TWO hours**

Answer ALL questions
Calculators are not permitted

1. (a) The interaction between an operating system and I/O devices can take place via busy waiting or using interrupts. Briefly describe the latter approach. [3 marks]

   (b) Briefly describe the Best Fit memory management algorithm, and point out one of its disadvantages when compared to First Fit. [4 marks]

   (c) Processes and threads are amongst the key concepts of operating systems.

   i. Briefly describe what a process is. [3 marks]

   ii. How does a thread differ from a process? Give two advantages of threads over processes. [3 marks]

   (d) Give a brief description of the algorithm for First Come, First Served scheduling in batch systems, and present one advantage and one disadvantage of using it. [6 marks]

   (e) Consider the concurrent program that consists of the following two processes that share the variable `x`:

```
P1:   x = 10;                  P2:   x = 4;
      if(x == 4)                     x = x - 7;
        x = x * 6;
```

   How many different values may the variable `x` have when the program terminates? Give a possible execution sequence for each case. [6 marks]

2. (a) Briefly describe what is a critical region in the context of concurrent programming. [5 marks]

   (b) There are four properties that are required for any correct algorithm to solve the mutual exclusion problem. List these whilst providing a brief description for each. [6 marks]

   (c) Consider the following proposed solution to the mutual exclusion problem for processes `P1` and `P2`, where variables `C1` and `C2` are both initially set to `1`:

```
P1:  LOOP
        LOOP UNTIL C2 = 1 END_LOOP;
        C1 := 0;
        Critical Region
        C1 := 1;
        Non-Critical Region
     END

P2:  LOOP
        LOOP UNTIL C1 = 1 END_LOOP;
        C2 := 0;
        Critical Region
        C2 := 1;
        Non-Critical Region
     END
```

   i. Briefly describe the operation of the algorithm, giving particular emphasis to any dependencies between the two processes. State whether this algorithm enforces strict alternation or not and justify your answer. [4 marks]

   ii. Give one example of execution order that shows the above algorithm does not fully comply with the conditions required for solving the mutual exclusion problem. [5 marks]

   (d) Briefly describe Peterson's algorithm for solving the mutual exclusion problem for two processes. [5 marks]

3. (a) Briefly describe two purposes of semaphores. [6 marks]

   (b) Explain how a semaphore's *up* and *down* operations can be implemented in a multiple CPU scenario whilst guaranteeing they are atomic. [4 marks]

   (c) Revisit the program shown in question 2, copied below:

```
P1:  LOOP
        LOOP UNTIL C2 = 1 END_LOOP;
        C1 := 0;
        Critical Region
        C1 := 1;
        Non-Critical Region
     END

P2:  LOOP
        LOOP UNTIL C1 = 1 END_LOOP;
        C2 := 0;
        Critical Region
        C2 := 1;
        Non-Critical Region
     END
```

   i. Write a revised version of that program using a semaphore. [5 marks]

   ii. What is gained by using a semaphore in that scenario? [4 marks]

   (d) Describe the goal of the message passing synchronisation mechanism, giving emphasis to when this is needed even in systems that support semaphores. Briefly describe how message passing works. [4 marks]

4. (a) Give a short definition of livelock in the context of concurrent programs. Describe an example where livelock can take place. You can use pseudocode for the example. [5 marks]

   (b) What is deadlock? Give an example to explain your definition. [5 marks]

   (c) In the context of deadlock avoidance algorithms:

      i. Describe what is meant by an unsafe state. [5 marks]

      ii. Consider the following states, assuming there is only one type of resource.

State X	Has	Max
A	2	4
B	1	3
C	1	3
D	0	1

State Y	Has	Max
A	2	3
B	0	5
C	1	4
D	1	5

Each row shows the information for a process. The columns show the number of resources held, and the maximum number of resources simultaneously required by each process. In both cases, there are a total of 5 resources in the system (some of which are being held as shown in the tables).

For each of the states (X and Y), indicate if it is a safe or unsafe state, and justify your classification. [4 marks]

   (d) State and briefly describe the four conditions that must all hold for a deadlock to exist. [8 marks]

END