King's College London

This paper is part of an examination of the College counting towards the award of a degree. Examinations are governed by the College Regulations under the authority of the Academic Board.

Degree Programmes	BSc, MSci
Module Code	5CCS2OSC
Module Title	Operating Systems and Concurrency
Examination Period	May 2018
Time Allowed	Two hours

Rubric **ANSWER ALL QUESTIONS.**

ANSWER SECTION A ON THE MULTIPLE CHOICE ANSWER SHEET PROVIDED, CAREFULLY FOLLOWING THE INSTRUCTIONS ON THE SHEET. YOU MUST USE A PENCIL TO WRITE ON THIS SHEET AND AN ERASER TO CORRECT ANY MISTAKES. WRITE YOUR CANDIDATE NUMBER IN THE SPACE PROVIDED, PRECEDED BY 000 AND ALSO REPLACING THE LETTER WITH 0, E.G. IF YOUR CANDIDATE NUMBER IS W12345, YOU WOULD WRITE 000012345. WRITE YOUR CANDIDATE NUMBER IN THE "NAME" BOX ON THE ANSWER SHEET (DO NOT WRITE YOUR REAL NAME). THE TEST NUMBER IS 090 AND THE COLLEGE NUMBER IS 10. THERE IS NO PENALTY FOR INCORRECT ANSWERS.

ANSWER SECTION B IN AN ANSWER BOOKLET START EACH QUESTION ON A NEW PAGE.

Calculators	Calculators may be used. The following models are permitted: Casio fx83 / Casio fx85.
Notes	Books, notes or other written material may not be brought into this examination

PLEASE DO NOT REMOVE THIS PAPER FROM THE EXAMINATION ROOM

Section B: Answer both Questions in this Section in your Answer Booklet

19. Concurrency (25 marks)

a. The code below models a sports hall that is used for different sports at different times. The code for the class SportsHall includes line numbers at the start of each line.

```
public class SportsPerson extends Thread {

  SportsHall hall;
  String sport,name;

  public SportsPerson(SportsHall hallIn,
                      String sportIn, String nameIn){
    hall = hallIn;
    sport = sportIn;
    name = nameIn;
  }

  public void run(){
    while(true){
      hall.enterSportsHall(this);
      hall.useSportsHall();
      hall.leaveSportsHall(this);
    }
  }

  public String getSport() {
    return sport;
  }

  public String getPersonName(){
    return name;
  }
}
```

QUESTION 19 CONTINUES ON NEXT PAGE

```
1:public class SportsHall {

2:  String currentSport = "Gymnastics";
3:  int users = 0;

4:  public synchronized void enterSportsHall(SportsPerson p){
5:      while(!p.getSport().equals(currentSport) && users > 0 ||
              p.getSport().equals("Gymnastics") && users >= 10 ||
              p.getSport().equals("Football") && users >= 22){

6:        try{
7:          wait();
8:        } catch (Exception e){
9:          e.printStackTrace();
10:       }
11:     }
12:     currentSport = p.getSport();
13:     ++users;
14:     System.out.println(p.getPersonName() + " entering hall");
15: }
16: public void useSportsHall() {
17:     try{
18:         Thread.sleep(10);
19:     } catch (Exception e){
20:         e.printStackTrace();
21:     }
22: }

25: public synchronized void leaveSportsHall(SportsPerson p) {
26:     --users;
27:     notifyAll();
28: }
29:}
```

QUESTION 19 CONTINUES ON NEXT PAGE

i. Write a main method that creates a `SportsHall` object, 30 `SportsPerson` objects with sport = "Gymnastics" and 30 with sport = "Football" (giving each a unique name) and runs them all as concurrent threads, using the same `SportsHall`.

[3 marks]

ii. What rules does the condition in the `while` loop at line 5 enforce for the use of the sports hall?

[2 marks]

iii. Suppose that instead of using a while loop at line 5 of SportsHall, the programmer had used an if statement (i.e. the word while is replaced by the word if at line 5), would the correct behaviour, i.e. that exhibited by the given code, be maintained? Explain your answer.

[3 marks]

iv. Returning to the written version with the while loop, what problem could occur if '`&& users > 0`' was not included in the condition of the while loop at line 5? Explain your answer.

[3 marks]

v. The current (unmodified) solution could lead to starvation of either footballers or gymnasts. Show how you would modify the code, including any new variables you would introduce and where you would update the values of these in order to create a solution that is guaranteed not to starve either footballers or gymnasts. You can use the line numbers in your explanation to avoid having to copy out code if you wish (e.g. increment variable var between lines 5 and 6).

[5 marks]

QUESTION 19 CONTINUES ON NEXT PAGE

b. This part of the question is about semaphores. Consider the following concurrent programme with 3 threads p,q, and r.

int v = 6		
p	q	r
p1: v = v/2	q0: v = v + 2 q1: v= v + 4	r0: v = v * 4

i. Explain how incorrect values of the shared variable v could arise (i.e. updates could be lost) if the arithmetic operations (+,* and /) were not atomic in this program.

[3 marks]

ii. Create a revised version of the pseudocode to show how you would use a semaphore to ensure that no two threads can modify the value of v in parallel, without causing the program to deadlock. You must show all places you would invoke semaphore methods to do this, as well as stating the initial value of the semaphore.

[3 marks]

iii. Starting again with the original pseudocode given in subquestion 36.b.i, create another version to show how you would use split semaphores to ensure that q and r can both execute concurrently when the program starts, but p must wait until both q and r have finished before it can begin execution. In this part of the question you can assume that the arithmetic operations are atomic and you need not enforce mutual exclusion on modifying v. Again you must show all places you would invoke semaphore methods to do this, as well as stating the initial value of any semaphores you use.

[3 marks]

20. Operating Systems (25 marks)

This question is related to protection and security.

a. i. What is the *need-to-know* principle? How can a protection system adhere to this principle if the association between a process and a domain is static?

[4 marks]

ii. Describe how Capability Lists are derived from an Access Matrix.

[2 marks]

b. Define each of the following concepts in one sentence.

i. Man-in-the-middle attack

[2 marks]

ii. Breach of confidentiality

[2 marks]

iii. Computer worm

[2 marks]

iv. Hash function

[2 marks]

QUESTION 20 CONTINUES ON NEXT PAGE

c. Alice, who often uses her company's secure mail server, has just lost her private key, but still has the corresponding public key.

i. Is Alice still able to send secret mail? Why?

[2 marks]

ii. Is Alice still able to decrypt secret mail she receives? Why?

[2 marks]

iii. Is Alice still able to sign the mail she sends? Why?

[2 marks]

iv. Is Alice still able to verify the signature of mail she receives? Why?

[2 marks]

v. Alice wants to send a message m to Bob. She creates a hash of the message $hash(m)$, encrypts this hash with Bob's public key, and sends the encrypted hash with the message m to Bob. Can Bob validate that the content of the message m has not been modified during transmission? Justify your answer.

[3 marks]