Calculators may be used in this examination provided they are not capable of being used to store alphabetical information other than hexadecimal numbers

UNIVERSITY OF BIRMINGHAM

School of Computer Science

LM Computer Systems (MSc)

Main January Examinations 2023

Time allowed: 2 hours

[Answer all questions]

Turn Over

Note

Answer ALL questions. Each question will be marked out of 20. The paper will be marked out of 60, which will be rescaled to a mark out of 100.

Question 1

(a) A Java method to calculate powers of 20 gives the following results.

```
n, 20^n
-------
0, 1
1, 20
2, 400
3, 8000
4, 160000
5, 3200000
6, 64000000
7, 1280000000
8, -169803776
```

Out of the possible types `short`, `int`, `long`, `float` and `double`, which one must the method be using for its calculation? Explain your answer.

Do an approximate calculation to explain why `n = 8` is the value for which the results start to go wrong. **[6 marks]**

(b) Describe the two techniques by which subroutine call and return instructions can be implemented. Outline an advantage or disadvantage of each technique. **[4 marks]**

(c) Consider the following Java-like program code:

```
int i, j, k = 0;
for (i = n / 2; i <= n; i++) {
    for (j = 2; j <= n; j = j * 2) {
        k = k + n / 2;
    }
}
for (i = n / 4; i <= n; i++) {
    k = k + 1;
}
```

What is the time complexity of this algorithm (using 'Big-O' notation)? Justify your answer. **[4 marks]**

(d) Consider the following Java bytecode:

```
public static int mystery(int);
 Code:
   0: iload_0
   1: iconst_2
   2: if_icmpgt     7
   5: iconst_1
   6: ireturn
   7: iload_0
   8: iconst_1
   9: isub
  10: invokestatic  #2          // Method mystery:(I)I
  13: iload_0
  14: iconst_2
  15: isub
  16: invokestatic  #2          // Method mystery:(I)I
  19: iadd
  20: ireturn
```

(i) Briefly explain what the `mystery` method is computing? For your ease, the bytecode lines have already been grouped together. You are expected to use the following format (copy this table to your answer book) while explaining the bytecode:

Bytecode Lines	**Explanation**
0-1	
2	
5-6	
7-10	
13-16	
19-20	

(ii) What will be the result, if the `mystery` method is called with a value of 4?

[6 marks]

Question 2

(a) What is a deadlock? As well as defining what it is, you should use an example to explain clearly how a deadlock situation can occur between a set of 3 processes. **[5 marks]**

(b) A program takes 800 seconds to run on a single core machine. Analysis shows that 20% of the program is inherently sequential and the remaining 80% consists of code that can, potentially, be run in parallel. If you had a processor with 10 cores, what is the minimum execution time that could be achieved? Explain why you would be very unlikely to achieve this speedup in practice. **[7 marks]**

(c) An e-commerce application sells shoes. The application stores the current stock level of each shoe in memory. When a pair of shoes is purchased a thread is created. The thread i) checks the current stock level for that shoe ii) calculates the new value and iii) updates the stock level. The stock level recorded is usually correct but occasionally the application shows an incorrect value.

(i) Explain the (technical) reason why the application occasionally shows an incorrect value. Use an example to illustrate your explanation.

(ii) Explain what changes should be made to the program to correct this behaviour.

(iii) After these changes, the system works correctly. However, the performance has degraded. Explain clearly why the performance will have got worse.

[8 marks]

Question 3

Alice wants to send a message to Bob. Alice and Bob communicate using the Internet, which has five layers in its protocol stack.

(a) Alice is not sure whether to encrypt her message using a symmetric key encryption system or a public key encryption system. Describe one advantage and one disadvantage of public key crypto compared to symmetric key crypto. Then, use these difference to justify which cryptographic system you think Alice should choose to encrypt her message. **[4 marks]**

(b) When the message is sent, the communication is initiated by Alice's messaging application process on the Application Layer. Explain what sockets are and how the Application Layer uses sockets to ensure that the message goes to the correct host (Bob) *and* the correct process (Bob's messaging application). **[3 marks]**

(c) The Transport Layer utilises TCP for Alice and Bob's communication. TCP is a connection-oriented protocol that provides a reliable flow of data between two computers. Before exchanging data, the client and server perform a "three-way handshake" in order to agree to establish a TCP connection.

Describe the three steps of the handshake, with particular reference at each stage to the states of the client and server, as well as the values of any variables used. **[8 marks]**

(d) Discuss the role and purpose of the Network Layer on both sides of Alice and Bob's communication. **[5 marks]**

End of Paper

Do not complete the attendance slip, fill in the front of the answer book or turn over the question paper until you are told to do so

Important Reminders

- Coats/outwear should be placed in the designated area.
- Unauthorised materials (e.g. notes or Tippex) must be placed in the designated area.
- Check that you do not have any unauthorised materials with you (e.g. in your pockets, pencil case).
- Mobile phones and smart watches **must** be switched off and placed in the designated area or under your desk. They must not be left on your person or in your pockets.
- You are not permitted to use a mobile phone as a clock. If you have difficulty seeing a clock, please alert an Invigilator.
- You are not permitted to have writing on your hand, arm or other body part.
- Check that you do not have writing on your hand, arm or other body part – if you do, you must inform an Invigilator immediately
- Alert an Invigilator immediately if you find any unauthorised item upon you during the examination.

Any students found with non-permitted items upon their person during the examination, or who fail to comply with Examination rules may be subject to Student Conduct procedures.