UNIVERSITY OF
WESTMINSTER

SCHOOL OF
COMPUTER SCIENCE & ENGINEERING

Module Title:	**Concurrent Programming**
Module Code:	**6SENG006W**
In-Class Test:	**18th January, 2023**
Start Time:	**11:00**
Submission Deadline:	**12:30**
RAF Submission Deadline:	**12:53**

INSTRUCTIONS FOR CANDIDATES

There are EIGHT questions in the test.

Answer ALL EIGHT questions.

Questions 1 - 4 are worth 10 marks each.

Questions 5 - 8 are worth 15 marks each.

YOU MUST SUBMIT YOUR ANSWERS BEFORE THE SUBMISSION DEADLINE.

Question 1

Explain what each of the following concurrency concepts mean:

(a) process

(b) asynchronous action

(c) nondeterminism

(d) interference

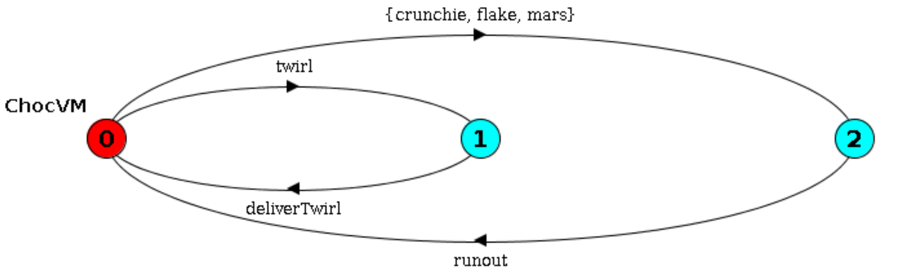
(e) individual starvation **[10 marks]**

[TOTAL 10]

Question 2

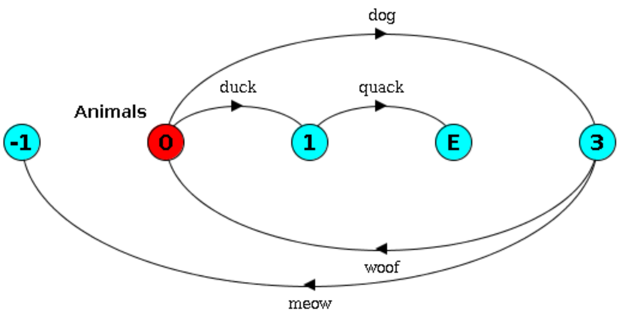
Give the FSP process definitions for the two processes `ChocVM` and `Animals` based on the following *Labelled Transition System (LTS)* graphs:

(a)



[5 marks]

(b)



[5 marks]

[TOTAL 10]

Question 3

(a) Briefly describe how a Java thread can be defined using the `Thread` class, including the rôle of the constructor and the code to be executed. **[6 marks]**

(b) Assume a novice Java concurrent programmer has created three Java threads called `manager`, `worker_1` and `worker_2`, the programmer then writes the following code to get them to execute concurrently:

```
manager.run()
worker_1.run()
worker_2.run()
```

Explain why this would not work and give the correct code to do this. **[4 marks]**

[TOTAL 10]

Question 4

(a) With reference to Dijkstra's *semaphore* concurrent programming mechanism. Explain the differences between a *mutex*, a *binary semaphore* and a *general semaphore*. **[3 marks]**

(b) Describe the operations that can be carried out on a semaphore. **[7 marks]**

[TOTAL 10]

Question 5

The following FSP program SYSTEM models two processes Successor and Predecessor sharing a Counter.

```
const MAX   = 3
range RANGE = 0..MAX

Counter ( N = 0 ) = CVal[N],

CVal[ cv : RANGE ] = (  when( cv < MAX ) succ -> CVal[ cv + 1 ]
                      | when( cv > 0 )   pred -> CVal[ cv - 1 ]
                      | succVal[cv] -> CVal[ cv ]
                      | predVal[cv] -> CVal[ cv ] ) .

Successor = (  succ -> Successor
             | succVal[ i : RANGE ] -> Successor ) .

Predecessor = (  pred -> Predecessor
               | predVal[ i : RANGE ] -> Predecessor ) .

||SYSTEM = ( Counter || Successor || Predecessor ) .
```

(a) Draw the alphabet diagram for SYSTEM. **[5 marks]**

(b) For each action state:

- the type of action: synchronous or asynchronous.
- all the processes that perform it.

[8 marks]

(c) What actions can be performed by the SYSTEM when the Counter's value is 3? **[2 marks]**

[TOTAL 15]

Question 6

In relation to the life-cycle states of a Java thread:

(a) List the possible states a Java thread can be in and give a brief description of each state. **[6 marks]**

(b) Explain the sequence of states and state transitions that an executing thread undergoes from the *point it fails to acquire a synchronisation lock*, to the point it is *available to be scheduled to execute*. **[4 marks]**

(c) Given the following code fragment:

```
public void synchronized method1()
{
      // A
      wait() ;
      // B
}
```

Explain the sequence of states and state transitions that a thread undergoes when executing the code starting at point `A` and ending at point `B`. **[5 marks]**

[TOTAL 15]

Question 7

With reference to the Java code for a simple variable class called `Variable` given in Appendix A, answer the following questions.

(a) State the modifications necessary to convert the `Variable` class into a secure and correctly functioning *monitor* class that would be safe to be used and shared by several threads in a multi-threaded Java program. **[8 marks]**

(b) Explain the purpose of the modifications you have made to the `Variable` class in part **(a)**. **[7 marks]**

[TOTAL 15]

Question 8

(a) Describe the Readers and Writers problem, and explain the concurrency issues that must be solved. **[5 marks]**

(b) Semaphores can be used to construct a correct solution for the Readers and Writers problem. Explain what semaphores are needed and what they are used for in a solution. **[10 marks]**

[TOTAL 15]

Appendix A

This appendix contains the Java code for an integer variable class.

```java
class Variable
{
   int     variable = 0 ;
   boolean updated  = false ;

   public int value()
   {
      while ( !updated )
      {
        try {
              System.out.println( "Cannot return old value" ) ;
              Thread.sleep(1000) ;
         } catch(InterruptedException e){ }
      }
      updated = false ;

      return variable ;
   }

   public void assign( int newValue )
   {
      while ( updated )
      {
         try {
               System.out.println( "Cannot overwrite new value" ) ;
               Thread.sleep(1000) ;
         } catch(InterruptedException e){ }
      }
      variable = newValue ;

      updated = true ;

    }
}
```

END OF THE IN-CLASS TEST PAPER