1. Which of the following Scala functions are tail-recursive? For those that are, give an equivalent function using iteration and no recursion.

```scala
val s: Int => Int = {  
    if (x == 0)  
        0  
    else  
        1 + s(x-1)
}

val t: Int => Int = {  
    if (x == 0)  
        0  
    else  
        t(x-1) + 1
}

val even: Int => Boolean = {  
    if (x == 0)  
        true  
    else if (x == 1)  
        false  
    else even(x-2)
}

val fac: Int => Int = {  
    if (x < 2)  
        1  
    else  
        x*fac(x-1)
}

val facn: Int => Int => Int = {  
    if (x < 2)  
        y  
    else  
        facn(x-1,x*y)
}

val fib: Int => Int = {  
    if (x < 2)  
        1  
    else  
        fib(n-1) + fib(n-2)
}
definition of the factorial function from a previous lecture:

```scala
def fac(x: Int) : Int = {
  if (x < 2) 1
  else x * fac(x - 1)
}
```

Use the recursion removal techniques described in lecture to convert this to a non-recursive Scala function using an explicit stack. It is easiest to develop a solution by first temporarily pretending that you have labels and gotos available in Scala, and then converting the resulting code to use structured control operators like `while`.

(b) Do the same with the Fibonacci function:

```scala
def fib(x: Int) : Int = {
  if (x < 2) x
  else
    fib(x - 1) + fib(x - 2)
}
```

Note: This example is much more complicated! In general, each entry in the explicit stack needs to encode which recursive call is to be “returned to,” and the values of any variables that are defined before the call.
and used after it. For fib, there are two “return points” corresponding to the two recursive calls. After returning from the first call we need to remember the value of \( n \) over the first call, and the value of \( t1 \) over the second call. A suitable Scala data type for stack elements is therefore:

```scala
sealed abstract class C
case class C1(val n : Int) extends C
case class C2(val t1 : Int) extends C
```