Foundations of Computer Science – Supervision 1

Question 1: (a) Why do we need types in programming languages?

(b) What is the type of the following values? Briefly justify:

(i) `let a x y = x`

(ii) `let b x y z = if x then y else z`

(iii) `let c x y = x y`

(iv) `let rec d _ x = d [ x ] true`

(c) Define values with the following types (without using type annotations):

(i) `'a -> 'a`

(ii) `int -> int list`

(iii) `('a -> 'b) -> ('b -> 'c) -> 'a -> 'c`

(iv) `('a -> 'b) -> 'a list -> 'b list`

Question 2: (a) For each function below, state its behaviour and its time and space complexities. Assume no compiler optimisation (tail-recursion doesn't count as compiler optimisation). Justify your answers.

(i)
```
let rec f pred l = match l with
  | [] -> 0
  | x :: xs -> if pred x then 1 else 0 + f pred xs
```

(ii) `let rec g n = if n > 1 then g (n - 1) + g (n - 2) else n`

Question 3: (a) Write a function that takes a positive integer n and returns a list of its factors. For example: `factors 12 = [1;2;3;4;6;12]`. The order of the factors in the list can be arbitrary, and you can assume that the argument is always positive.

(b) What is the time complexity of your algorithm? Can you think of a way to improve it?

Question 4: Link to past paper question

Question 5: (a) Implement the following utility functions on lists. Make sure that all recursive calls are tail-recursive:

(i) reverse:

`reverse [x1;...;xn] is [xn;...;x1]`

(ii) map:

```
map f [x1;...;xn] is [f(x1);...;f(xn)]
```

(iii) filter: filter p l is the list containing the elements of l that satisfy the predicate p, in the order that they appear in l.

(iv) left fold:

```
fold_left f a [b1;b2;...;bn]
= f (... (f (f a b1) b2) ...) bn
```