

2 Foundations of Computer Science (rkh23)

A $W \times H$ matrix can be represented in OCaml by a *flat list*: a list that concatenates the rows in order. For each of the following alternative ways to represent a 2D matrix in OCaml:

- State the type T of the representation;
- Give a function `create w m: int -> float list -> T` that constructs the matrix of type T equivalent to the input flat list m with row width w ;
- Give a function `get r c m: int -> int -> T -> float` that gets the element of the matrix m at row r and column c .
- State the asymptotic complexity of the `get` function in terms of W and H

(a) A list of lists. [5 marks]

(b) An array of arrays. [6 marks]

(c) A functional array of functional arrays. [9 marks]

Your answers may use the `List` module and assume this functional array code:

```
type 'a tree = Lf | Br of 'a * 'a tree * 'a tree;;
exception Subscript;;
```

```
let rec update = function
  | Lf, k, w ->
    if k = 1 then
      Br (w, Lf, Lf)
    else
      raise Subscript
  | Br (v, t1, t2), k, w ->
    if k = 1 then
      Br (w, t1, t2)
    else if k mod 2 = 0 then
      Br (v, update (t1, k / 2, w), t2)
    else
      Br (v, t1, update (t2, k / 2, w));;
```

```
let rec sub = function
  | Lf, _ -> raise Subscript
  | Br (v, t1, t2), 1 -> v
  | Br (v, t1, t2), k when k mod 2 = 0 -> sub (t1, k / 2)
  | Br (v, t1, t2), k -> sub (t2, k / 2);;
```