COL226: Programming Languages

Mon 11 Apr 2022 **MajorQ1** 5+9 (+3 for PwD) minutes Max marks 10

Instructions:

1. Download the paper and write your name and entry number in the designated space on top and *do not forget to sign the honour statement below.*
2. Answer the question(s). *Answers will be judged for correctness, efficiency and elegance.*
4. If there are minor mistakes in the question, correct them explicitly and answer the question accordingly. If the question is totally wrong, give adequate reasons why it is wrong with detailed counter-examples, if necessary.
4. Scan the paper with your completed answer.
5. Upload it on Gradescope 2102-COL226 page within the given time. *Make sure the first page with your name, entry no and signature is also the first page of your uploaded file*
6. Late submissions (within 2 minutes of submission deadline) on the portal will attract a penalty of 10% of the total marks allotted to the paper for each minute of delay and 20% for each minute of delay thereafter.
7. Email submissions after the closing of the portal will not be evaluated (You get a 0).
8. Uploads without the first page details (including signature) may be awarded 0 marks.

I abide by the Honour code that I have signed on my admission to IIT Delhi. I have neither given any help to anybody nor received any help from anybody nor from any site or other sources in solving the question(s) in this paper.

Signature: **Date:**

[5 × 2 = 10 marks]

Study the program `sortCheck` written to check whether a program `sort` correctly sorts a list according to an irreflexive total ordering relation `R`. The identifiers have obvious intended meanings. Now answer the following questions.

1. What is the principal type of the function `sortCheck`?
2. What is the bug in the definition of `isOrdered`? Give an example to illustrate that `isOrdered` is wrong.
3. Write the corrected code for `isOrdered`.
4. `isOrdered` is defined in the scope `let-1` but may be required for purposes other than `sortCheck`. Redefine the function `isOrdered` in the scope marked `global` so that it is globally available.
5. What is the type of the new globally defined function `isOrdered`?

```
(* global *)
local (* local-0 *)
    local (* local-1 *)
        fun  delete (a, []) = (false, [])
           | delete (a, h::T) =
             if  (a = h) then (true, T)
             else
                 let val (isIn, T') = delete (a, T)
                 in  if isIn then (true, h::T')
                     else (false, h::T)
                 end
    in
    fun  isPermutation ([], []) = true
       | isPermutation ([], _)  = false
       | isPermutation (_, []) =  false
       | isPermutation (a::L, b::M) =
         if (a = b) then isPermutation (L, M)
         else
             let (* let-2 *)
```

```
                val (wasIn, M') = delete (a, M)
            in  wasIn andalso isPermutation (L, b::M')
            end (* let-2 *)
    end (* local-1 *)
in
fun sortCheck sort R L =
    let (* let-1 *)
        fun  isOrdered [] = true
           | isOrdered [h]= true
           | isOrdered (h1::h2::t) =
             R(h1, h2) andalso isOrdered (h2::t)
        val  M = sort R L
    in  isOrdered M andalso isPermutation (L, M)
    end (* let-1 *)
end (* local-0 *)
(* global *)
```