Programming Language, Assignment 3
Due: April 23th, 11:59 pm

Submission

Write the functions in problem 1 – 3 in a single file, named "sol3.sml".
Then upload the file to the course homepage (assignment 3). The function names (and their types) should be the same as is described for each problem. There should be no error when using the file in repl with the following command: use "sol3.sml";
Because we are going to test your solution with an automated script, if our script cannot import your file with [use "sol3.sml"] then your score for this assignment will be zero. So, make sure you test your code.

Problems

The problem 1 and 2 use the following type definitions, which are similar to the pattern matching in ML:

```
datatype pattern = Wildcard | Variable of string | UnitP
                 | ConstP of int | TupleP of pattern list
                 | ConstructorP of string * pattern

datatype valu = Const of int | Unit | Tuple of valu list
              | Constructor of string * valu
```

Given `valu v` and `pattern p`, either `p matches v` or not. If it does, the match produces a list of `string * valu` pairs; order in the list does not matter. The rules for matching should be unsurprising:

- `Wildcard` matches everything and produces the empty list of bindings.
- `Variable s` matches any value v and produces the one-element list holding `(s,v)`.
- `UnitP` matches only `Unit` and produces the empty list of bindings.
- `ConstP 17` matches only `Const 17` and produces the empty list of bindings (and similarly for other integers).
- `TupleP ps` matches a value of the form `Tuple vs` if `ps` and `vs` have the same length and for all `i`, the i^{th} element of `ps` matches the i^{th} element of `vs`. The list of bindings produced is all the lists from the nested pattern matches appended together.
- `ConstructorP(s1,p)` matches `Constructor(s2,v)` if `s1` and `s2` are the same string (you can compare them with =) and `p` matches `v`. The list of bindings produced is the list from the nested pattern match. We call the strings `s1` and `s2` the `constructor` name.
- Nothing else matches.

1. `check_pat` (20 pts)

Write a function `check_pat` that takes a pattern and returns true if and only if all the variables appearing in the pattern are distinct from each other (i.e., use different strings). The constructor names are not relevant. Hints: The sample solution uses two helper functions. The first takes a pattern and returns a list of all the strings it uses for variables. Using `foldl` with a function that uses append is useful in one case. The second takes a list of strings and decides if it has repeats. `List.exists` may be useful. You don't have to use `foldl` and `List.exists`, but those functions make it easier.

```
val check_pat = fn : pattern -> bool
```

2. `match` (20 pts)

Write a function `match` that takes a `valu * pattern` and returns a `(string * valu) list option`, namely `NONE` if the pattern does not match and `SOME lst` where `lst` is the list of bindings if it does match; `string * valu` tuple represents the variable name (`string`) for the value (`valu`). Note that if the value matches but the pattern has no patterns of the form `Variable s`, then the result is `SOME []`. Hints: Sample solution has one case expression with 7 branches. The branch for tuples uses `List.filter` (to get the list of elements satisfying a condition) and `ListPair.zip`. You don't have to use `List.filter` and `ListPair.zip` here, but they make it easier.

```
val match = fn : valu * pattern -> (string * valu) list
option
```

3. You will implement the tournament of Rock, Paper, Scissors game. The followings are the data types we define to implement the tournament:

```
type name = string

datatype RSP =
     ROCK
   | SCISSORS
   | PAPER


datatype 'a strategy = Cons of 'a * (unit -> 'a strategy)

datatype tournament =
     PLAYER of name * (RSP strategy ref)
   | MATCH of tournament * tournament
```

RSP strategy is a stream of RSP, which, when called, gives a pair of RSP and a function closure that will give the next item in the stream. The following variables (r, s, p, rp, etc) are example RSP strategies, and the function next retrieves one RSP value from the given RSP strategy.

```
fun onlyOne(one:RSP) = Cons(one, fn() => onlyOne(one))

fun alterTwo(one:RSP, two:RSP) = Cons(one, fn() =>
alterTwo(two, one))

fun alterThree(one:RSP, two:RSP, three:RSP) = Cons(one, fn()
=> alterThree(two, three, one))


val r = onlyOne(ROCK)

val s = onlyOne(SCISSORS)

val p = onlyOne(PAPER)

val rp = alterTwo(ROCK, PAPER)

val sr = alterTwo(SCISSORS, ROCK)

val ps = alterTwo(PAPER, SCISSORS)

val srp = alterThree(SCISSORS, ROCK, PAPER)


fun next(strategyRef) =
    let val Cons(rsp, func) = !strategyRef in
        strategyRef := func();
        rsp
    end
```

In this question, you are asked to implement whosWinner function, which takes a tournament as its parameter and returns the winner of the tournament. For example, for the following code,

```
val winner = whosWinner(MATCH(PLAYER("s", ref s),
          MATCH(PLAYER("rp", ref rp), PLAYER("r", ref r))));
```

whosWinner returns a player who won the tournament, that is, PLAYER("rp", ref rp) above.

Use pattern matching (case expressions) to implement whosWinner function.

```
fun whosWinner(t) =
```