

## CSE 341, Spring 2011, Assignment 2

### Due: Thursday 14 April, 11:00PM

You will write 11 SML functions (not counting local helper functions), 4 having to do with “name substitutions” and 7 having to do with a made-up solitaire card game.

Your solutions must use pattern-matching. You may not use the functions `null`, `hd`, or `tl`, nor may you use anything containing a `#` character. You may not use mutation. The sample solution is about 135 lines, *including* all the code provided to you.

Download *hw2provided.sml* from the course website. The provided code defines several types for you. You do not need to define any additional types.

Do not miss the “Important Caveat” after the “Type Summary.”

1. This problem involves using first-name substitutions to come up with alternate names. For example, *Fredrick William Flintstone* could also be *Fred William Flintstone* or *Freddie William Flintstone*. Only part (d) is specifically about this, but the other problems are helpful.

- (a) Write a function `all_except_option`, which takes a `string` and a `string list`. Return `NONE` if the string is not in the list, else return `SOME lst` where `lst` is like the argument list except the string is not in it. You may assume the string is in the list at most once. Use `same_string`, provided to you, to compare strings. Sample solution is 8 lines.
- (b) Write a function `get_substitutions1`, which takes a `string list list` (a list of list of strings, the *substitutions*) and a `string s` and returns a `string list`. The result has all the strings that are in some list in *substitutions* that also has `s`, but `s` itself should not be in the result. Example:

```
get_substitutions1([["Fred", "Fredrick"], ["Elizabeth", "Betty"], ["Freddie", "Fred", "F"]],
                  "Fred")
(* answer: ["Fredrick", "Freddie", "F"] *)
```

Assume each list in *substitutions* has no repeats. The result will have repeats if `s` and another string are both in more than one list in *substitutions*. Example:

```
get_substitutions1([["Fred", "Fredrick"], ["Jeff", "Jeffrey"], ["Geoff", "Jeff", "Jeffrey"]],
                  "Jeff")
(* answer: ["Jeffrey", "Geoff", "Jeffrey"] *)
```

Use part (a) and ML’s list-append (`@`) but no other helper functions. Sample solution is 6 lines.

- (c) Write a function `get_substitutions2`, which behaves like `get_substitutions1` except it uses a tail-recursive local helper function.
- (d) Write a function `similar_names`, which takes a `string list list` of substitutions (as in parts (b) and (c)) and a *full name* of type `{first:string,middle:string,last:string}` and returns a list of full names (of type `{first:string,middle:string,last:string} list`). The result is all the full names you can produce by substituting for the first name (and *only the first name*) using *substitutions* and parts (b) or (c). The answer should always begin with the original name (then have 0 or more other names). Example:

```
similar_names([["Fred", "Fredrick"], ["Elizabeth", "Betty"], ["Freddie", "Fred", "F"]],
              {first="Fred", middle="W", last="Flintstone"})
(* answer: [{first="Fred", middle="W", last="Flintstone"},
           {first="Fredrick", middle="W", last="Flintstone"},
           {first="Freddie", middle="W", last="Flintstone"},
           {first="F", middle="W", last="Flintstone"}] *)
```

Hint: Use a local helper function. Sample solution is 9 lines.

2. This problem involves a solitaire card game made up by a past CSE 341 instructor. You will write a program that tracks the progress of a game; writing a game player is a challenge problem. You can do parts (a)–(e) before understanding the game if you wish.

A game is played with a *card-list* and a *goal*. The player has a list of *held-cards*, initially empty. The player makes a move by either *drawing*, which means removing the first card in the card-list from the card-list and adding it to the held-cards, or *discarding*, which means choosing one of the held-cards to remove. The game ends either when the player chooses to make no more moves or when the sum of the values of the held-cards is greater than the goal.

The objective is to end the game with a low score (0 is best). Scoring works as follows: Let *sum* be the sum of the values of the held-cards. If *sum* is greater than *goal*, the *preliminary score* is three times  $sum - goal$ , else the preliminary score is  $goal - sum$ . The score is the preliminary score unless all the held-cards are the same color, in which case the score is the preliminary score divided by 2 (and rounded down as usual with integer division; use ML's `div` operator).

- (a) Write a function `card_color`, which takes a card and returns its color (spades and clubs are black, diamonds and hearts are red). Note: One case-expression is enough.
- (b) Write a function `card_value`, which takes a card and returns its value (numbered cards have their number as the value, aces are 11, everything else is 10). Note: One case-expression is enough.
- (c) Write a function `remove_card`, which takes a list of cards `lst`, a card `c`, and an exception `e`. It returns a list that has all the elements of `lst` except `c`. If `c` is in the list more than once, remove only the first one. If `c` is not in the list, raise the exception `e`. You can compare cards with `=`.
- (d) Write a function `all_same_color`, which takes a list of cards and returns true if all the cards in the list are the same color. Hint: An elegant solution is very similar to one of the functions we looked at in lecture 6.
- (e) Write a function `sum_cards`, which takes a list of cards and returns the sum of their values. *Use a locally defined helper function that is tail recursive.*
- (f) Write a function `score`, which takes a `card list` (the held-cards) and an `int` (the goal) and computes the score as described above.
- (g) Write a function `officiate`, which “runs a game.” It takes a `card list` (the card-list) a `move list` (what the player “does” at each point), and an `int` (the goal) and returns the score at the end of the game after processing (some or all of) the moves in the move list in order. Use a locally defined recursive helper function that takes several arguments that together represent the current state of the game. As described above:
  - The game starts with the held-cards being the empty list.
  - The game ends if there are no more moves. (The player chose to stop since the `move list` is empty.)
  - If the player discards some card `c`, play continues (i.e., make a recursive call) with the held-cards not having `c` and the card-list unchanged. If `c` is not in the held-cards, raise the `IllegalMove` exception.
  - If the player draws and the card-list is empty, the game is over. Else if drawing causes the sum of the held-cards to exceed the goal, the game is over. Else play continues with a larger held-cards and a smaller card-list. Sample solution is under 20 lines.

### 3. Challenge Problems:

- (a) Write `score_challenge` and `officiate_challenge` to be like their non-challenge counterparts except each ace can have a value of 1 or 11 and `score_challenge` should always return the least (i.e., best) possible score. Hint: This is easier than you might think.
- (b) Write `careful_player`, which takes a card-list and a goal and returns a move-list such that calling `officiate` with the card-list, the goal, and the move-list has this behavior:
  - The value of the held cards never exceeds the goal.
  - A card is drawn whenever the goal is more than 10 greater than the value of the held cards.
  - If a score of 0 is reached, there must be no more moves.
  - If it is possible to discard one card, then draw one card to produce a score of 0, then this must be done. (Note `careful_player` will have to look ahead to the next card, which in many card games is considered “cheating.”)

#### Type Summary

Evaluating a correct homework solution should generate these bindings, in addition to the bindings from the code provided to you — *but see the important caveat that follows!*

```
val all_except_option = fn : string * string list -> string list option
val get_substitutions1 = fn : string list list * string -> string list
val get_substitutions2 = fn : string list list * string -> string list
val similar_names = fn : string list list * {first:string, last:string, middle:string}
  -> {first:string, last:string, middle:string} list
val card_color = fn : card -> color
val card_value = fn : card -> int
val remove_card = fn : card list * card * exn -> card list
val all_same_color = fn : card list -> bool
val sum_cards = fn : card list -> int
val score = fn : card list * int -> int
val officiate = fn : card list * move list * int -> int
```

*Important Caveat:* The read-eval-print loop may give your functions *equivalent types* or *more general types*. This is fine. In the sample solution, the bindings for problems 1d, 2a, 2b, 2c, and 2d were all more general. For example, `card_value` had type `suit * 'a -> color` and `remove_card` had type `'a list * 'a * exn -> 'a list`. They are more general, which means there is a way to replace the *type variables* (`'a` or `'a`) with types to get the bindings listed above. As for equivalent types, because type `card = suit*rank`, types like `card -> int` and `suit*rank->int` are equivalent. They are the same type, and the read-eval-print loop simply chooses one way of printing the type. Also, the order of fields in records never matters.

If you write down explicit argument types for functions, you will probably not see equivalent or more-general types, but the sample solution takes the common ML approach of omitting all explicit types.

Of course, generating these bindings does not guarantee that your solutions are correct. *Test your functions.*

#### Assessment

Your solutions should be correct, in good style (including indentation and line breaks), and using features we have used in class.

#### Turn-in Instructions

- Put all your solutions in one file, `hw2.sml`.
- The first line of your `.sml` file should be an ML comment with your name and the phrase `homework 2`.
- Turn in your file using the Catalyst dropbox link on the course website.