You will write 12 SML functions (and tests for them) related to calendar dates. In all problems, a “date” is an SML value of type \texttt{int*int*int}, where the first part is the day, the second part is the month, and the third part is the year. A “reasonable” date has a positive year, a month between 1 and 12, and a day no greater than 31 (or less depending on the month). Your solutions need to work correctly only for reasonable dates, but do not check for reasonable dates (that is a challenge problem) and many of your functions will naturally work correctly for some/all non-reasonable dates. A “day of year” is a number from 1 to 365 where, for example, 33 represents February 2. (We ignore leap years except in one challenge problem.)

1. Write a function \texttt{is_older} that takes two dates and evaluates to true or false. It evaluates to true if the first argument is a date that comes before the second argument. (If the two dates are the same, the result is false.)

2. Write a function \texttt{number_in_month} that takes a list of dates and a month (i.e., an \texttt{int}) and returns how many dates in the list are in the given month.

3. Write a function \texttt{number_in_months} that takes a list of dates and a list of months (i.e., an \texttt{int list}) and returns the number of dates in the list of dates that are in any of the months in the list of months. \texttt{Assume the list of months has no number repeated}. Hint: Use your answer to the previous problem.

4. Write a function \texttt{dates_in_month} that takes a list of dates and a month (i.e., an \texttt{int}) and returns a list holding the dates from the argument list of dates that are in the month. The returned list should contain dates in the order they were originally given.

5. Write a function \texttt{dates_in_months} that takes a list of dates and a list of months (i.e., an \texttt{int list}) and returns a list holding the dates from the argument list of dates that are in any of the months in the list of months. \texttt{Assume the list of months has no number repeated}. Hint: Use your answer to the previous problem and SML’s list-append operator (\texttt{@}).

6. Write a function \texttt{get_nth} that takes a list of strings and an \texttt{int} \texttt{n} and returns the \texttt{n}th element of the list where the head of the list is 1st. Do not worry about the case where the list has too few elements: your function may apply \texttt{hd} or \texttt{tl} to the empty list in this case, which is okay.

7. Write a function \texttt{date_to_string} that takes a date and returns a string of the form \texttt{September-10-2015} (for example). Use the operator \texttt{^} for concatenating strings and the library function \texttt{Int.toString} for converting an \texttt{int} to a \texttt{string}. For producing the month part, do \texttt{not} use a bunch of conditionals. Instead, use a list holding 12 strings and your answer to the previous problem. For consistency, use hyphens exactly as in the example and use English month names: January, February, March, April, May, June, July, August, September, October, November, December.

8. Write a function \texttt{number_before_reaching_sum} that takes an \texttt{int} called \texttt{sum}, which you can assume is positive, and an \texttt{int list}, which you can assume contains all positive numbers, and returns an \texttt{int}. You should return an \texttt{int} \texttt{n} such that the first \texttt{n} elements of the list add to less than \texttt{sum}, but the first \texttt{n} + 1 elements of the list add to \texttt{sum} or more. Assume the entire list sums to more than the passed in value; it is okay for an exception to occur if this is not the case.

9. Write a function \texttt{what_month} that takes a day of year (i.e., an \texttt{int} between 1 and 365) and returns what month that day is in (1 for January, 2 for February, etc.). Use a list holding 12 integers and your answer to the previous problem.

10. Write a function \texttt{month_range} that takes two days of the year \texttt{day1} and \texttt{day2} and returns an \texttt{int list} \texttt{[m1,m2,...,mn]} where \texttt{m1} is the month of \texttt{day1}, \texttt{m2} is the month of \texttt{day1+1}, ..., and \texttt{mn} is the month of day \texttt{day2}. Note the result will have length \texttt{day2 - day1 + 1} or length 0 if \texttt{day1>day2}.

11. Write a function \texttt{oldest} that takes a list of dates and evaluates to an \texttt{(int*int*int) option}. It evaluates to \texttt{NONE} if the list has no dates else \texttt{SOME} \texttt{d} where the date \texttt{d} is the oldest date in the list.
12. Write a function \texttt{cumulative\_sum} that takes a list of numbers and returns a list of the partial sums of these numbers. For example, \texttt{cumulative\_sum [12,27,13]} = \texttt{[12,39,52]}. Hint: Use a helper function that takes two arguments.

13. **Challenge Problem:** Write functions \texttt{number\_in\_months\_challenge} and \texttt{dates\_in\_months\_challenge} that are like your solutions to problems 3 and 5 except having a month in the second argument multiple times has no more effect than having it once. (Hint: Remove duplicates, then use previous work.)

14. **Challenge Problem:** Write a function \texttt{reasonable\_date} that takes a date and determines if it describes a real date in the common era. A “real date” has a positive year (year 0 did not exist), a month between 1 and 12, and a day appropriate for the month. Solutions should properly handle leap years. Leap years are years that are either divisible by 400 or divisible by 4 but not divisible by 100. (Do not worry about days possibly lost in the conversion to the Gregorian calendar in the Late 1500s.)

Note: Remember the course policy on challenge problems.
Note: The sample solution contains \textit{roughly} 90–100 lines of code, not including challenge problems.

**Summary**

Evaluating a correct homework solution should generate these bindings:

\begin{verbatim}
val is_older = fn : (int * int * int) * (int * int * int) -> bool
val number_in_month = fn : (int * int * int) list * int -> int
val number_in_months = fn : (int * int * int) list * int list -> int
val dates_in_month = fn : (int * int * int) list * int list -> (int * int * int) list
val dates_in_months = fn : (int * int * int) list * int list -> (int * int * int) list
val get_nth = fn : string list * int -> string
val date_to_string = fn : int * int * int -> string
val number_before_reaching_sum = fn : int * int list -> int
val what_month = fn : int -> int
val month_range = fn : int * int -> int list
val oldest = fn : (int * int * int) list -> (int * int * int) option
val cumulative_sum = fn : int list -> int list
\end{verbatim}

Of course, generating these bindings does not guarantee that your solutions are correct. \textit{Test your functions: Put your testing code in a separate file. We will not grade the testing file, but you must turn it in.}

**Assessment**

Solutions should be:

- Correct
- In good style, including indentation and line breaks
- Written using features discussed in class. In particular, you must \textit{not} use SML’s mutable references or arrays. (Why would you?) Also do \textit{not} use pattern-matching; it is the focus of the next assignment.

**Turn-in Instructions**

- Put all your solutions in one file, \texttt{hw1.sml}. Put tests you wrote in \texttt{hw1.test.sml}.
- Follow the dropbox link on the course website (homework section), follow the “Homework 1” link, and upload your files.

**Syntax Hints**

Small syntax errors can lead to strange error messages. Here are 3 examples for function definitions:

1. \texttt{int * int * int list} means \texttt{int * int * (int list)}, not \texttt{(int * int * int) list}.
2. \texttt{fun f x : t} means the \textit{result type} of \texttt{f} is \texttt{t}, whereas \texttt{fun f \ (x:t)} means the \textit{argument type} of \texttt{f} is \texttt{t}. There is no need to write result types (and in later assignments, no need to write argument types).
3. \texttt{fun \ (x t), fun \ (t x), or fun \ (t : x)} are all wrong, but the error message suggests you are trying to do something much more advanced than you actually are (which is trying to write \texttt{fun \ (x : t)}).

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