Practice Problems for Section 5

NOTE: You do not need to handle corner cases, particularly receiving arguments of the wrong type, unless explicitly asked to do that in the problem statement.

Warm Up

Knights Who Say 'Ni'

I'm sure you saw this coming. We want... another factorial!

Write a function `factorial` that takes a single non-negative integer number n as an argument and evaluates to $n!$.

EXAMPLE: `(factorial 4)` evaluates to `24`

Another Shrubbery!

Now do it again. But your solution must be tail-recursive!

Name your function `tr-factorial`.

EXAMPLE: `(tr-factorial 4)` evaluates to `24`

Palindromic Addition

Write a function `palindromic` that takes a list of numbers and evaluates to a list of numbers of the same length, where each element is obtained as follows: the first element should be the sum of the first and the last elements of the original list, the second one should be the sum of the second and second to last elements of the original list, etc.

EXAMPLE: `(palindromic (list 1 2 4 8))` evaluates to `(list 9 6 6 9)`

Streams

We're going to use the same definition of streams here as in the lectures and in the homework assignment. There are no examples in this sub-section, as providing useful examples would require defining some extra stream functions – which you should do on your own for practice! If you really want to see some examples, take a peek at provided tests, but beware of **SPOILERS**!

HINT: You may want to scour the reading notes for useful stream functions. Yes, using stuff found in the class materials is fair play.

Undecided

Define a stream `undecided` that starts with a `#t` and then alternates between `#f` and `#t` infinitely.

Fibonacci

Define a stream `fibonacci`, the first element of which is `0`, the second one is `1`, and each successive element is the sum of two immediately preceding elements.

Interleave (*)

Write a function `interleave` that takes two streams `xs` and `ys` and evaluates to another stream, such that the first element of it is the first element of `xs`, the second element is the first element of `ys`, the third element is the second element of `xs` etc. For example, (`interleave fibonacci undecided`) would evaluate to a stream the elements of which would be, in order: `0`, `#t`, `1`, `#f`, `1`, `#t`, `2`, `#f`...

Not These Guys Again

Ni!!! We want... another factorial. Recall **A Novel Approach** problem from Section 3. The unfortunate issue with that implementation of factorial function was that it used up extra $O(n)$ space due to explicit building of a list of all numbers from 1 to n.

Write a function `stream-factorial` that will compute the factorial by multiplying the numbers from the infinite stream of all natural numbers, in $O(1)$ space.

HINT: You may want to borrow an implementation of an infinite stream of natural numbers from class materials. Or you could write your own from scratch for extra practice.

EXAMPLE: (`stream-factorial 4`) evaluates to `24`

More Bananas

Write a function `repeats` that takes a string and evaluates to a stream the first element of which is the original string, the second is the string repeated twice etc. This is similar to **BananaBanana − Continued** problems in Standard ML sections, but instead of a finite list we're producing an infinite stream of repeats. (Note that we could do the same in Standard ML had we defined an appropriate stream datatype. You may try to do that as a challenge.)

Newton's Back For More

We'll revisit the **Newton's Method** problem from Section 3, but instead of returning a single result we will produce an infinite stream of approximations.

Write a function `sqrt-stream` that takes a number n, starts with n as an initial guess in the stream, and produces successive guesses applying $f_n(x) = \frac{1}{2}(x + \frac{n}{x})$ to the current guess. Guesses sufficiently far into the stream should be very close to $\sqrt{n}$.

Macros

Perl Style

Write a macro `perform` that has the following two forms:

```
(perform e1 if e2)
(perform e1 unless e2)
```

`e1` should be evaluated (once) depending on the result of evaluating `e2` – only if `e2` evaluates to `#f` in the latter case, and only if it doesn't in the former case. If `e1` is never evaluated, the entire expression should evaluate to `e2`. Neither `e1` nor `e2` should be evaluated more than once in any case.

HINT: You may want to take a look at special forms for conjunction and/or disjunction in the standard lib.

EXAMPLE: `(perform (print "can't happen!") unless null)` evaluates to `null`, producing no side effects

(*) Problems contributed by Charilaos Skiadas.