CSE341 – Section 3

Standard-Library Docs, Unnecessary Function Wrapping, Map, & More

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   - Standard Basis
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Standard Basis Documentation

Online Documentation

http://www.standardml.org/Basis/index.html
http://www.smlnj.org/doc/smlnj-lib/Manual/toc.html

Helpful Subset

Top-Level	http://www.standardml.org/Basis/top-level-chapter.html
List	http://www.standardml.org/Basis/list.html
ListPair	http://www.standardml.org/Basis/list-pair.html
Real	http://www.standardml.org/Basis/real.html
String	http://www.standardml.org/Basis/string.html

Interlude

Questions

- How's life?
- Tail-recursion?
- Pattern-matching?

Note

- Extra Lecture Material: http://www.cs.washington.edu/education/courses/cse341/13wi/videos/unit3/

Anonymous Functions

An Anonymous Function

```
fn pattern => expression
```

- An expression that creates a new function with no name.
- Usually used as an argument to a higher-order function.
- Almost equivalent to the following:

```
let fun name pattern = expression in name end
```

- **The difference is that anonymous functions cannot be recursive!!!**

Simple Example

```
fun doSomethingWithFive f = f 5;
val x1 = doSomethingWithFive (fn x => x*2); (* x1=10 *)
val x2 = (fn x => x+9) 6;                   (* x2=15 *)
val cube = fn x => x*x*x;
val x3 = cube 4;                            (* x3=12 *)
val x4 = doSomethingWithFive cube;          (* x4=15 *)
```

Anonymous Functions

What's the difference between the following two bindings?

```
val name = fn pattern => expression;
fun name pattern = expression;
```

- Once again, the difference is recursion.
- However, excluding recursion, a **fun** binding could just be syntactic sugar for a **val** binding and an anonymous function.
- This is because there are no recursive **val** bindings in SML.

Anonymous Functions (cont.)

Previous Example

```
fun n_times (f,n,x) = if n=0
                      then x
                      else f (x_times (f, n-1, x));

fun square x = x*x;
fun increment x = x+1;

val x1 = n_times (square, 4, 7);
val x2 = n_times (increment, 4, 7);
val x3 = n_times (tl, 2, [4,8,12,16]);
```

With Anonymous Functions

```
val x1 = n_times (fn x => x*x, 4, 7);
val x2 = n_times (fn x => x+1, 4, 7);
val x3 = n_times (fn xs => tl xs, 2, [4,8,12,16]); (* Bad Style *)
```

Unnecessary Function Wrapping

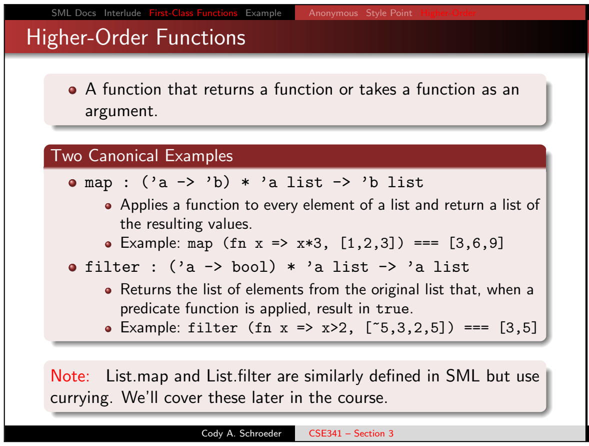
What's the difference between the following two expressions?

`(fn xs => tl xs)` vs. `tl`

STYLE POINTS!

- Other than style, these two expressions result in the exact same thing.
- However, one creates an unnecessary function to wrap tl.
- This is very similiar to this style issue:

`(if ex then true else false)` vs. `ex`



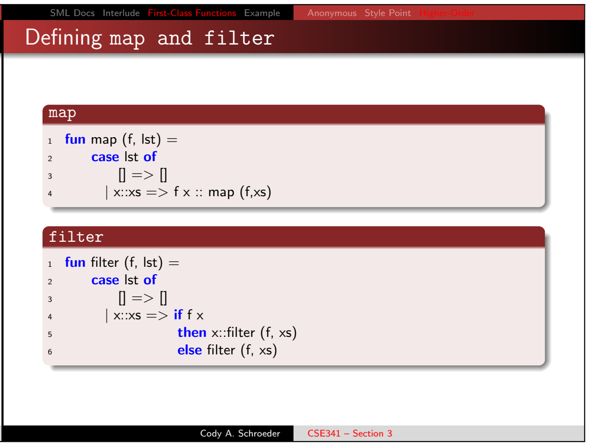
Higher-Order Functions

- A function that returns a function or takes a function as an argument.

Two Canonical Examples

- `map : ('a -> 'b) * 'a list -> 'b list`
  - Applies a function to every element of a list and return a list of the resulting values.
  - Example: `map (fn x => x*3, [1,2,3]) === [3,6,9]`
- `filter : ('a -> bool) * 'a list -> 'a list`
  - Returns the list of elements from the original list that, when a predicate function is applied, result in `true`.
  - Example: `filter (fn x => x>2, [~5,3,2,5]) === [3,5]`

Note: List.map and List.filter are similarly defined in SML but use currying. We'll cover these later in the course.



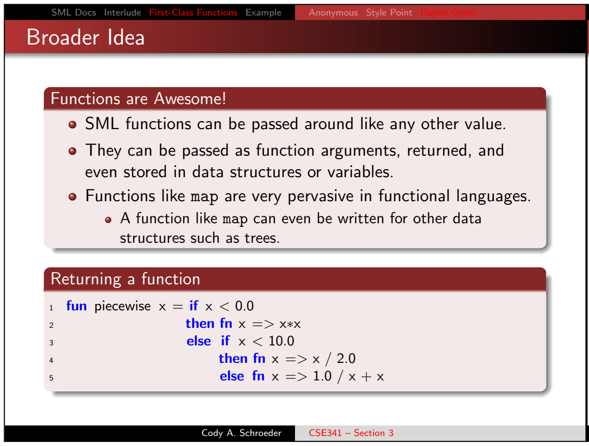
Defining `map` and `filter`

`map`

```
fun map (f, lst) =
    case lst of
        [] => []
      | x::xs => f x :: map (f,xs)
```

`filter`

```
fun filter (f, lst) =
    case lst of
        [] => []
      | x::xs => if f x
                 then x::filter (f, xs)
                 else filter (f, xs)
```



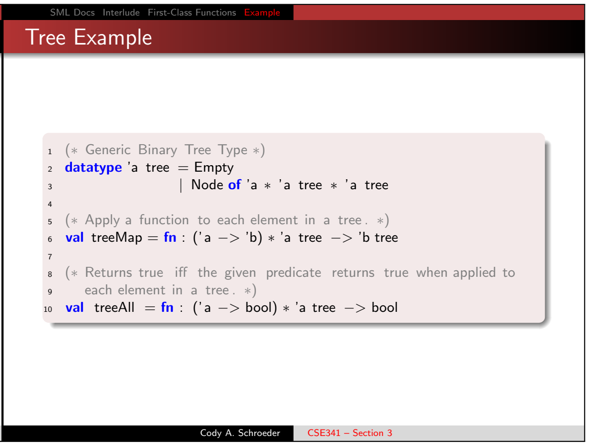
Broader Idea

Functions are Awesome!

- SML functions can be passed around like any other value.
- They can be passed as function arguments, returned, and even stored in data structures or variables.
- Functions like `map` are very pervasive in functional languages.
  - A function like `map` can even be written for other data structures such as trees.

Returning a function

```
fun piecewise x = if x < 0.0
                  then fn x => x*x
                  else if x < 10.0
                       then fn x => x / 2.0
                       else fn x => 1.0 / x + x
```



Tree Example

```
(* Generic Binary Tree Type *)
datatype 'a tree = Empty
                 | Node of 'a * 'a tree * 'a tree

(* Apply a function to each element in a tree. *)
val treeMap = fn : ('a -> 'b) * 'a tree -> 'b tree

(* Returns true iff the given predicate returns true when applied to
   each element in a tree. *)
val treeAll = fn : ('a -> bool) * 'a tree -> bool
```

exp Example

```
(* Modified expression datatype from lecture 5. Now there are
   variables. *)
datatype exp = Constant of int
             | Negate of exp
             | Add of exp * exp
             | Multiply of exp * exp
             | Var of string

(* Do a post-order traversal of the given exp. At each node, apply a
   function f to it and replace the node with the result. *)
val visitPostOrder = fn : (exp -> exp) * exp -> exp

(* Simplify the root of the expression if possible. *)
val simplifyOnce = fn : exp -> exp

(* Almost the same as evaluate but leaves variables alone. *)
val simplify = fn : exp -> exp
```