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Additional notes and functions are listed on the bottom.

```
1. (* Alternate input from 2 lists into a single list
       Ex: alternate([1,3,5],[2,4,6]) -> [1,2,3,4,5,6]*)
   fun alternate([],[]) = []
    | alternate(x::xs, y::ys) = x::y::alternate(xs, ys);
2. (* Minus input integer lists
       Ex: input([1,1,1,2,2],[1,1,2,3])
           minus([1,1,1,2,2],[1,1,2,3]) = [1,2] integers in common
           minus([1,1,1,2,2],[1,1,2,3]) = [3] after removing common integers*
   *)
   fun delete(x, []) = [](*removes an element from a list*)
       | delete(x,y::l) = if x=y then delete(x,l) else y::delete(x,l);
   fun removeDuplicate [] = [](*removes all duplicate elements*)
       | removeDuplicate (x::l) = x::removeDuplicate(delete(x,l));
   fun remove (_, []) = [](*Assumes all elements are unique*)
       | remove (x, y::ys) = if x = y then ys
           else y :: remove (x,ys);
   fun filter ([],    ys) = ys
       | filter (x::xs, ys) =
       let
           val ysWithoutX = remove (x, ys)
       in  (*filter([1,2,3],[1,4,2,6,3,7]) -
   > [4,6,7]  must have unique elements*)
           filter(xs, ysWithoutX)
       end;
   fun minus(x,y) = filter(removeDuplicate(x), removeDuplicate(y));
3. (* Union input two lists and output union of the two without duplication*)
       Ex: Union([1,1,1,2,2],[1,1,2,3]) = [1,2,3]
       Ex2:Union([h,e,l,l,o],[w,o,r,l,d]) = [h,e,l,o,w,r,d]
   fun delete(x, []) = [](*removes an element from a list*)
       | delete(x,y::l) = if x=y then delete(x,l) else y::delete(x,l);
   fun removeDuplicate [] = [](*removes all duplicate elements*)
       | removeDuplicate (x::l) = x::removeDuplicate(delete(x,l));
   fun flatten [] = []
       | flatten (x::l) = x @ flatten l;
   fun union(x,y) = removeDuplicate(flatten[x,y]);
4. (* Intersection takes in multiple sets and creates a list of matching elem
   ents in all sets
       Ex: Intersect([[1,1,1,2,2],[1,1,2,3],[2,3,5,5],[3,5,7,4]]) = [] there
   is no overlaping element in all sets *)
   fun member(x,[]) = false(*if at end of list, return false base case*)
       | member(x,b::y) =(*checks element x against element b from list y, si
   milar to for loop check*)
```

```
        if x=b then true(*positive match*)
        else member(x,y);
fun aux([],x) = []
    | aux(x::xs,ys) =
        if member(x,ys)then x::aux(xs,ys)
        else aux(xs,ys);
fun multiSetIntersection([]) = []
    | multiSetIntersection([xs]) = xs
    | multiSetIntersection (xs::xss) = aux(xs, multiSetIntersection(xss));
```

```
5. (* Cartesian Product Function
```

```
    Ex: S1 = {a,b,c}
        S2 = {1,2}
        S1xS2 = {(a,1),(a,2),(b,1),(b,2),(c,1),(c,2)}*)
        (*hint: *)

fun prodBlock ([],_) = [](*takes 2 sets and multiplies eachother, returns
new set*)
    | prodBlock ((x::xs), ys) = map (fn y => (x,y)) ys @ prodBlock (xs, ys
)
fun Cartesian zs = foldl (fn (xs, ys) => map op:: (prodBlock (xs, ys))) [[
]] (rev zs);
(*Fold video: Notable slides SML 190 - fold.pptx*)
```

```
6. (* Powerlist set
```

```
    Ex: S = {1,2}
        PowS = {{1,2},{1},{2},{}} *)
(*I got help on this function, time was running short*)

fun powerset [] = [](*base case if empty*)
    | powerset [x] = [[],[x]](**)
    | powerset (x::xs) =
    let
        val power_subset = powerset xs(*creates val which is the next recu
rsive step*)
    in
        (List.map (fn L => x::L) power_subset) @ power_subset(*appends sub
set to current set*)
    end;

fun union (e, [] : ''a list) : ''a list = [e]
    | union (e, x::xs) =
    if e = x then x::xs
    else x::union(e, xs)
fun insert (e : ''a, [] : ''a list list) : ''a list list = []
    | insert (e, s::ss) = union(e, s)::insert(e, ss)
fun Powerlist [] = [](*core function base case*)
```

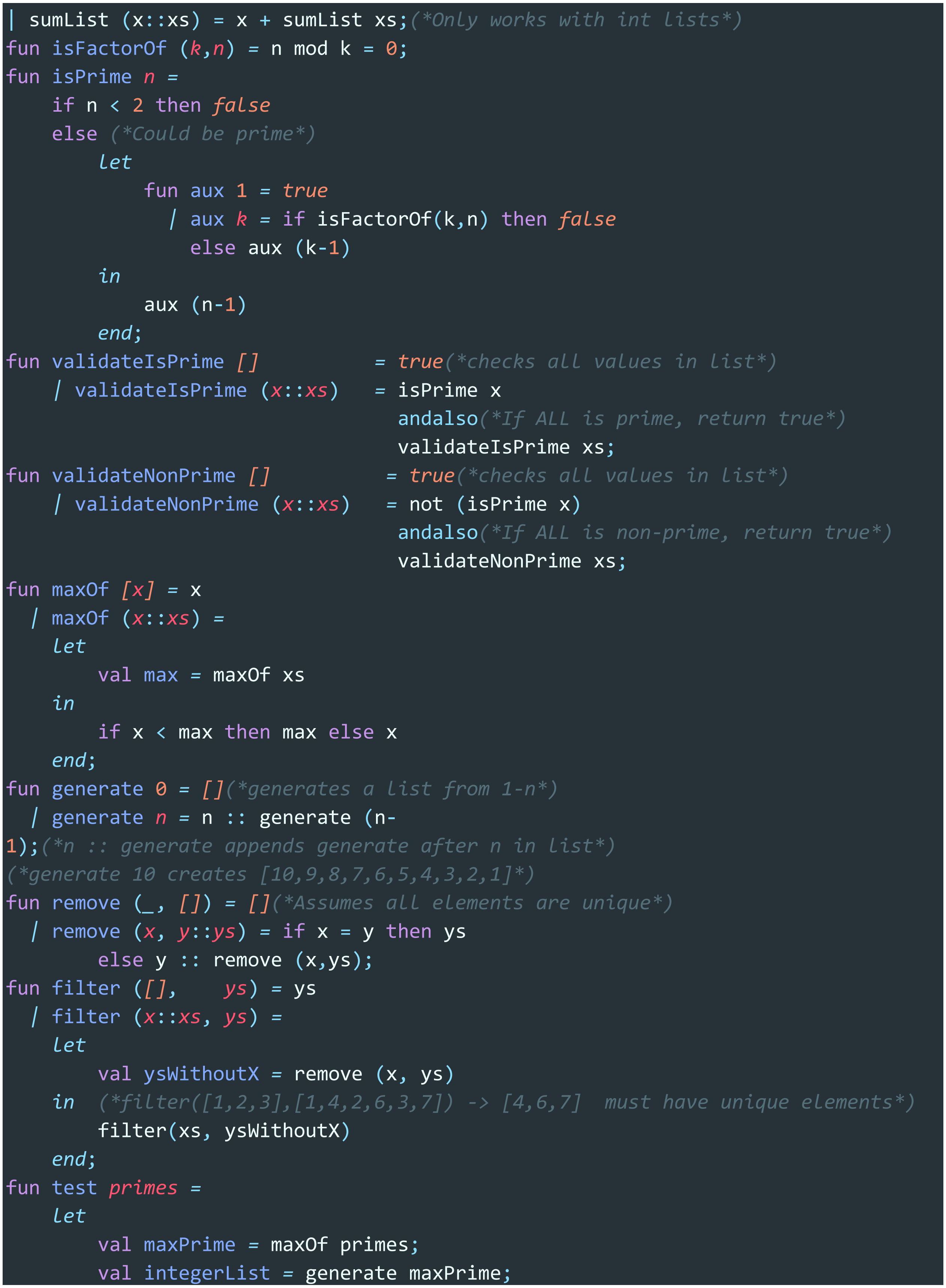
```
    | Powerlist [x] = [[],[x]]
    | Powerlist (x::xs) =
    let
        val power_subset = powerset xs
    in
        power_subset @ insert(x, power_subset)
    end;
```

```
7. (* finiteListRepresentation takes in a function and number X
    Returns the function output for first X times
    Ex: FLR( posIntSqr, 5 ) = [(1,1),(2,4),(3,9),(4,16),(5,25)]
    Simpple generator??!?*)
fun reverse [] = []
    | reverse (x::xs) = reverse xs @ [x];
fun generate 0 = [](*easy to understand recursive loop*)
    | generate n = [[n,n*n]]@generate (n-1);
fun FLR(x) = reverse(generate x);
```

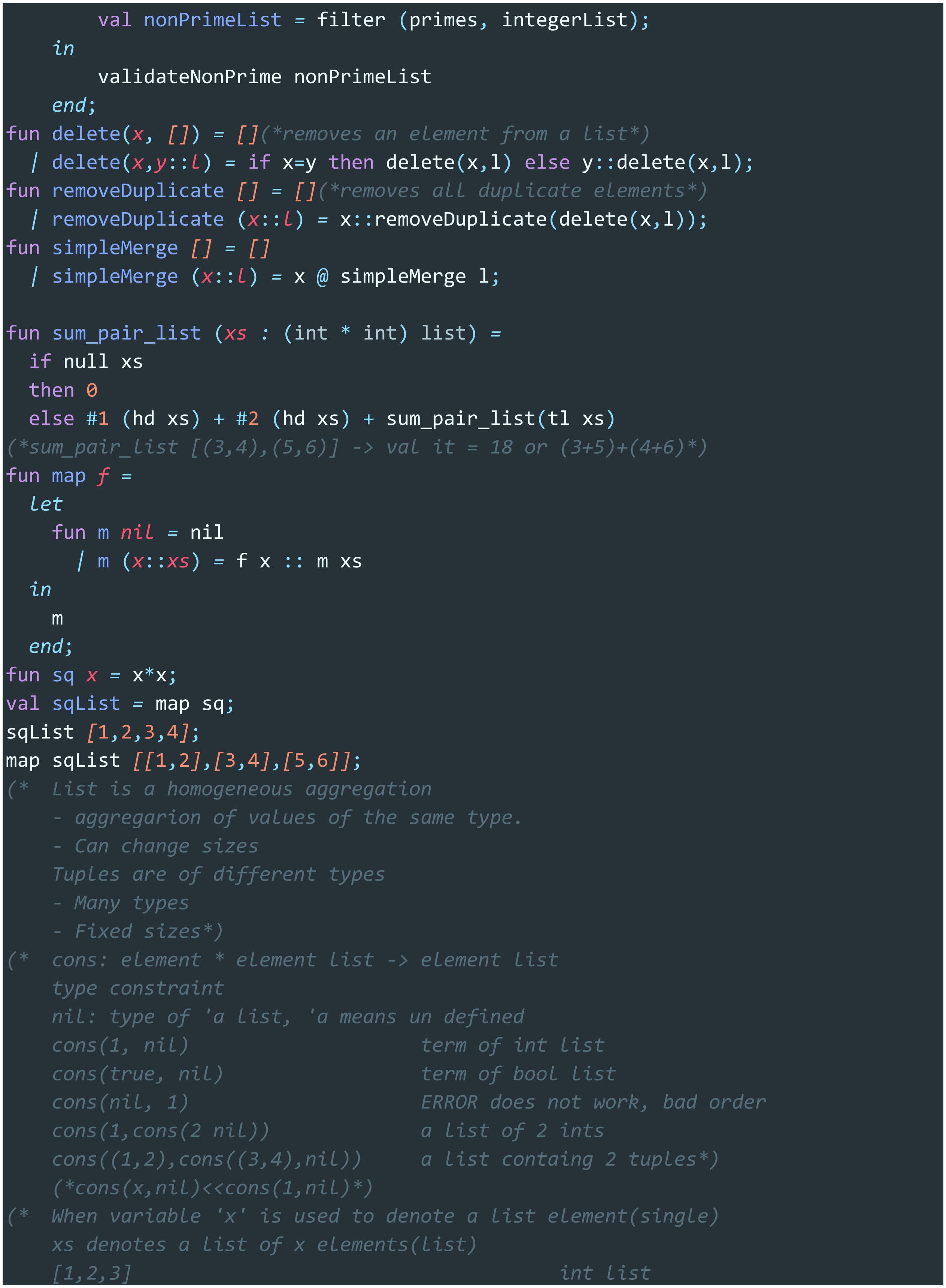
```
8. (* Update SML function: Updates a finite list with new values
    Ex: Let FLR = [(1,1),(2,4),(3,9),(4,16),(5,25)]
        update(FLR, (2,3)) = [(1,1),(2,3),(3,9),(4,16),(5,25)]
```

NOTES:

```
(* Our first SML program *)
print "\n\nhello world\n\n";
fun isEven  n = n mod 2 = 0;
fun succ    n = if isEven n then n div 2 else 3 * n + 1;

fun maxOf (v, w) = if v < w then w else v;

fun threeN n =
    let
        val trackFn = maxOf

        fun aux (1,max) = trackFn (1,max)
        |   aux (n,max) = aux( succ n, trackFn(n,max) )
    in
        aux( n, 0 )
    end;

threeN 7;
fun length [] = 0(*Recursive program with a 0 base case*)
| length (x::xs) = 1 + length xs;(*if exists, then 1 + next level*)
(* to return "length [1,2,3]" is equivalent to an int value*)
(*[1,2,3] can be substituted with any list*)
(* visual output (1+(1+(1+0))) = 3*)
fun sumList [] = 0(*Similar to length, except adds value in list*)
```



```
| sumList (x::xs) = x + sumList xs;(*Only works with int lists*)
fun isFactorOf (k,n) = n mod k = 0;
fun isPrime n =
    if n < 2 then false
    else (*Could be prime*)
        let
            fun aux 1 = true
              | aux k = if isFactorOf(k,n) then false
                else aux (k-1)
        in
            aux (n-1)
        end;
fun validateIsPrime []          = true(*checks all values in list*)
    | validateIsPrime (x::xs)   = isPrime x
                                  andalso(*If ALL is prime, return true*)
                                  validateIsPrime xs;
fun validateNonPrime []          = true(*checks all values in list*)
    | validateNonPrime (x::xs)   = not (isPrime x)
                                  andalso(*If ALL is non-prime, return true*)
                                  validateNonPrime xs;
fun maxOf [x] = x
  | maxOf (x::xs) =
    let
        val max = maxOf xs
    in
        if x < max then max else x
    end;
fun generate 0 = [](*generates a list from 1-n*)
  | generate n = n :: generate (n-
1);(*n :: generate appends generate after n in list*)
(*generate 10 creates [10,9,8,7,6,5,4,3,2,1]*)
fun remove (_, []) = [](*Assumes all elements are unique*)
  | remove (x, y::ys) = if x = y then ys
        else y :: remove (x,ys);
fun filter ([],    ys) = ys
  | filter (x::xs, ys) =
    let
        val ysWithoutX = remove (x, ys)
    in  (*filter([1,2,3],[1,4,2,6,3,7]) -> [4,6,7]  must have unique elements*)
        filter(xs, ysWithoutX)
    end;
fun test primes =
    let
        val maxPrime = maxOf primes;
        val integerList = generate maxPrime;
```



```
        val nonPrimeList = filter (primes, integerList);
    in
        validateNonPrime nonPrimeList
    end;
fun delete(x, []) = [](*removes an element from a list*)
  | delete(x,y::l) = if x=y then delete(x,l) else y::delete(x,l);
fun removeDuplicate [] = [](*removes all duplicate elements*)
  | removeDuplicate (x::l) = x::removeDuplicate(delete(x,l));
fun simpleMerge [] = []
  | simpleMerge (x::l) = x @ simpleMerge l;

fun sum_pair_list (xs : (int * int) list) =
  if null xs
  then 0
  else #1 (hd xs) + #2 (hd xs) + sum_pair_list(tl xs)
(*sum_pair_list [(3,4),(5,6)] -> val it = 18 or (3+5)+(4+6)*)
fun map f =
  let
    fun m nil = nil
      | m (x::xs) = f x :: m xs
  in
    m
  end;
fun sq x = x*x;
val sqList = map sq;
sqList [1,2,3,4];
map sqList [[1,2],[3,4],[5,6]];
(*  List is a homogeneous aggregation
    - aggregarion of values of the same type.
    - Can change sizes
    Tuples are of different types
    - Many types
    - Fixed sizes*)
(*  cons: element * element list -> element list
    type constraint
    nil: type of 'a list, 'a means un defined
    cons(1, nil)                    term of int list
    cons(true, nil)                 term of bool list
    cons(nil, 1)                    ERROR does not work, bad order
    cons(1,cons(2 nil))             a list of 2 ints
    cons((1,2),cons((3,4),nil))     a list containg 2 tuples*)
    (*cons(x,nil)<<cons(1,nil)*)
(*  When variable 'x' is used to denote a list element(single)
    xs denotes a list of x elements(list)
    [1,2,3]                                     int list
    [(1,true),(2,false),(3,true)] (int*bool)    list or a tuple list
    [[1,2],[3],[4,5,6]]                         int list list
    []                                          empty list
    Evaluation is left to right
    -Operand :: = 'a *'a list -
> 'a list         takes and element on the left and a list on the right then adds
 the element to the front of the list
    -Operand @ = 'a list * 'a list -
> 'a list    takes two lists and concatonates the second onto the end of the firs
t
    Ex: 1::[]       -> [1]
    Ex: 2::[1]      -> [2,1]
    Ex: 1::2::[]    -> [1,2]
    Ex: 1::[2]::3   -> fails, bad order
    Ex: [1]@[2]     -> [1,2]
    Ex: []@[1]      -> [1]
    Ex: special []::[]->[[]]*)
(*  hd [x] is the first element of the list
    tl [x] is the list after the "head"*)
```