Functional Decomposition

COS 326

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Functional Decomposition

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Break down complex problems in to a set of simple functions;
Recombine (compose) functions to form solution

Such problems can often be solved using a *combinator library*.
(a set of functions that fit together nicely)

The list library, which contains *map* and *fold*, is a combinator library.

PIPELINES

Pipe

```
let (|>) x f = f x ;;
```

Type?

Pipe

```
let (|>) x f = f x ;;
```

Type?

```
(|>) : 'a -> ('a -> 'b) -> 'b
```

Pipe

```
let (|>) x f = f x ;;
```

```
let twice f x =
   x |> f |> f;;
```

Pipe

```
let (|>) x f = f x ;;
```

```
let twice f x =
  (x |> f) |> f;;
```

left associative: x |> f1 |> f2 |> f3 == ((x |> f1) |> f2) |> f3

Pipe

```
let (|>) x f = f x ;;
```

```
let twice f x =
  x |> f |> f;;
```

```
let square x = x*x;;
```

```
let fourth x = twice square;;
```

Pipe

```
let (|>) x f = f x ;;
```

```
let twice f x = x |> f |> f;;
let square x = x*x;;
let fourth x = twice square x;;

let compute x =
  x |> square
    |> fourth
    |> ( * ) 3
    |> print_int
    |> print_newline;;
```

PIPING LIST PROCESSORS

(Combining combinators cleverly)

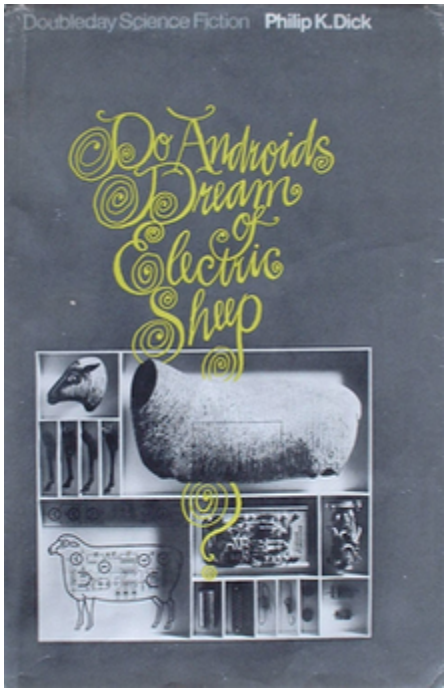
Another Problem

```
type student = {first:  string;
                last:   string;
                assign: float list;
                final:  float};;

let students : student list =
  [
   {first  = "Sarah";
    last   = "Jones";
    assign = [7.0;8.0;10.0;9.0];
    final  = 8.5};

   {first  = "Qian";
    last   = "Xi";
    assign = [7.3;8.1;3.1;9.0];
    final  = 6.5};
  ]
;;
```

Another Problem

```
type student = {first:   string;
                last:    string;
                assign:  float list;
                final:   float};;
```

- Create a function display that does the following:
  - for each student, print the following:
    - last_name, first_name: score
    - score is computed by averaging the assignments with the final
      - each assignment is weighted equally
      - the final counts for twice as much
    - one student printed per line
    - students printed in order of score



(1968 novel)

Do Professors Dream of Homework-grade Databases ?

Another Problem

Create a function display that

- takes a list of students as an argument
- prints the following for each student:
  - last_name, first_name: score
  - score is computed by averaging the assignments with the final
    - each assignment is weighted equally
    - the final counts for twice as much
  - one student printed per line
  - students printed in order of score

```
let display (students : student list) : unit =
  students |> compute score
           |> sort by score
           |> convert to list of strings
           |> print each string
```

Another Problem

```
let compute_score
 {first=f; last=l; assign=grades; final=exam} =

  let sum x (num,tot) = (num +. 1., tot +. x) in

  let score gs e = List.fold_right sum gs (2., 2. *. e) in

  let (number, total) = score grades exam in
  (f, l, total /. number)
;;
```

```
let display (students : student list) : unit =
  students |> List.map compute_score
           |> sort by score
           |> convert to list of strings
           |> print each string
```

Another Problem

```
let student_compare (_,_,score1) (_,_,score2) =
  if score1 < score2 then 1
  else if score1 > score2 then -1
  else 0
;;
```

```
let display (students : student list) : unit =
  students |> List.map compute_score
           |> List.sort compare_score
           |> convert to list of strings
           |> print each string
```

Another Problem

```
let stringify (first, last, score) =
  last ^ ", " ^ first ^ ": " ^ string_of_float score;;
```

```
let display (students : student list) : unit =
  students |> List.map compute_score
           |> List.sort compare_score
           |> List.map stringify
           |> print each string
```

Another Problem

```
let stringify (first, last, score) =
  last ^ ", " ^ first ^ ": " ^ string_of_float score;;
```

```
let display (students : student list) : unit =
  students |> List.map compute_score
           |> List.sort compare_score
           |> List.map stringify
           |> List.iter print_endline
```

COMBINATORS FOR OTHER TYPES: PAIRS

Simple Pair Combinators

```
let both   f (x,y) = (f x, f y);;
let do_fst f (x,y) = (f x,   y);;
let do_snd f (x,y) = (  x, f y);;
```

pair combinators

Example: Piping Pairs

```
let both   f (x,y) = (f x, f y);;
let do_fst f (x,y) = (f x,   y);;
let do_snd f (x,y) = (  x, f y);;

let even x = (x/2)*2 == x;;

let process (p : float * float) =
  p |> both int_of_float       (* convert to int   *)
    |> do_fst ((/) 3)          (* divide fst by 3  *)
    |> do_snd ((/) 2)          (* divide snd by 2  *)
    |> both even               (* test for even    *)
    |> fun (x,y) -> x && y     (* both even        *)
```

pair combinators

Summary

- (|>) passes data from one function to the next
  - compact, elegant, clear

- UNIX pipes (|) compose file processors
  - unix scripting with | is a kind of functional programming
  - but it isn't very general since | is not polymorphic
  - you have to serialize and unserialize your data at each step
    - there can be uncaught type (ie: file format) mismatches between steps
    - we avoided that in your assignment, which is pretty simple …

- Higher-order *combinator libraries* arranged around types:
  - List combinators (map, fold, reduce, iter, …)
  - Pair combinators (both, do_fst, do_snd, …)
  - Network programming combinators (Frenetic: frenetic-lang.org)