Review: “Continuation-Passing Style”

All tail positions are continuations or recursive calls

```
(define witness-cps (p? xs succ fail)
   (if (null? xs)
       (fail)
       (let ([z (car xs)])
         (if (p? z)
             (succ z)
             (witness-cps p? (cdr xs) succ fail)))))
```

Compiles to tight code

Homework: Solving Boolean formulas

A formula is one of these:

- **Symbol (stands for a variable)**
- **Record `(make-not` f`)`; f is a formula**
- **Record `(make-or` fs`)`; fs is a list of formulas**
- **Record `(make-and` fs`)`; fs is a list of formulas**

In context of:

```
(record not [arg])
(record or  [args])
(record and [args])
```

Your turn: Find satisfying assignment!

```
(val f1 (make-and (list4 'x 'y 'z (make-not 'x))))
   ; x /\ y /\ z /\ !x

(val f2 (make-not (make-or (list2 'x 'y))))
   ; !(x \/ y)

(val f3 (make-not (make-and (list3 'x 'y 'z))))
   ; !(x /\ y /\ z)
```

Wait for it ...

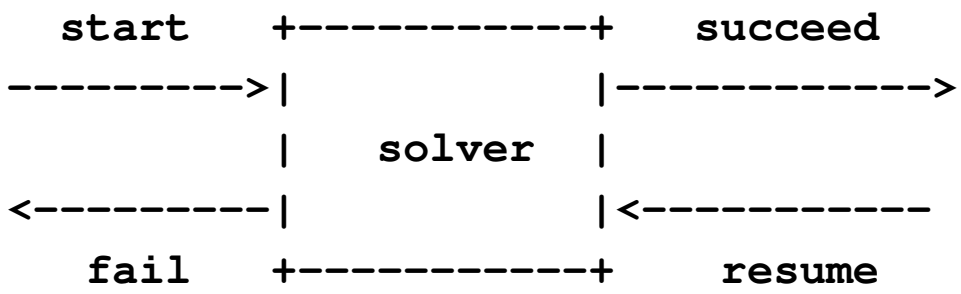
Satisfying assignments

```
(val f1 (make-and (list4 'x 'y 'z (make-not 'x))))
   ; x /\ y /\ z /\ !x  ;; NONE

(val f2 (make-not (make-or (list2 'x 'y))))
   ; !(x \/ y)           ;; { x |-> #f, y |-> #f }

(val f3 (make-not (make-and (list3 'x 'y 'z))))
   ; !(x /\ y /\ z)      ;; { x |-> #f, ... }
```

Find assignment using continuations



start Gets partial solution, `fail`, `succeed`
(On homework, "solution" is assignment)

`fail` Partial solution won't work (no params)

`succeed` Gets improved solution + `resume`

`resume` If improved solution won't work,
try another (no params)

A composable unit!

Continuations for the solver

A big box contains two smaller boxes A and B

There are two ways to wire them up (board)

Imagine A and B as formulas

Imagine A as a formula, B as a *list* of formulas!

Solving a literal

```
; (satisfy-literal-true x current succ fail) =
;   (succ current fail), when x is bound to #t in cur
;   (fail),                when x is bound to #f in cur
;   (succ (bind x #t current) fail), x unbound in cur

(define satisfy-literal-true (x current succ fail)
  (if (bound? x current)
      (if (find x current)
          (succ current fail)
          (fail))
      (succ (bind x #t current) fail)))
```

Lisp and Scheme Retrospective

Five powerful questions

1. What is the abstract syntax?
   Syntactic categories? Terms in each category?
2. What are the values?
   What do expressions/terms evaluate to?
3. What environments are there?
   What can names stand for?
4. How are terms evaluated?
   Judgments? Evaluation rules?
5. What's in the initial basis?
   Primitives and predefined, what is built in?

μScheme and the Five Questions

Abstract syntax: expressions and definitions
imperative core, `let`, `lambda`

Values: S-expressions
(especially `cons` cells, function closures)

Environments: A name stands for a mutable location holding a value

Evaluation rules: `lambda` captures environment

Initial basis: yummy higher-order functions

Full Scheme: Macros

A Scheme program is *just another S-expression*

- Function `define-syntax` manipulates syntax at compile time
- Macros are hygienic—name clashes impossible
- `let`, `&&`, `record`, others implemented as macros

(See book sections 2.16, 2.17.4)

Full Scheme: Conditionals

```
(cond [c1 e1]     ; if c1 then e1
      [c2 e2]     ; else if c2 then e2
       ...             ...
      [cn en])    ; else if cn then en

; Syntactic sugar---'if' is a macro:
(if e1 e2 e3) == (cond [e1 e2]
                       [#t e3])
```

Full Scheme: Mutation

Not only variables can be mutated.

Mutate heap-allocated cons cell:

```
(set-car! '(a b c) 'd)  => (d b c)
```

Circular lists, sharing, avoids allocation

- still for specialists only