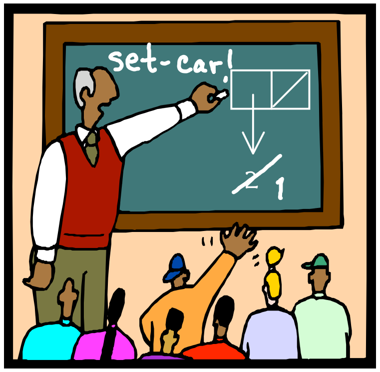
6.001 recitation 11 3/21/07

- stack, queue problems



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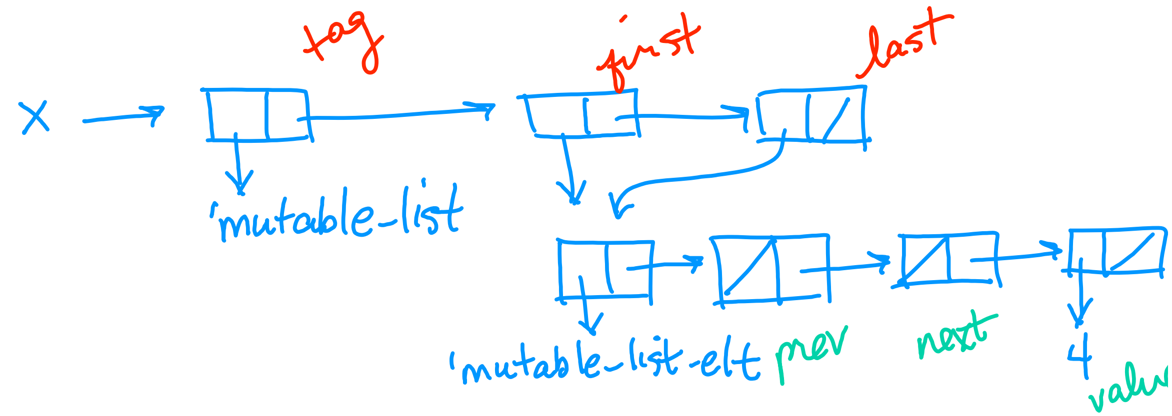
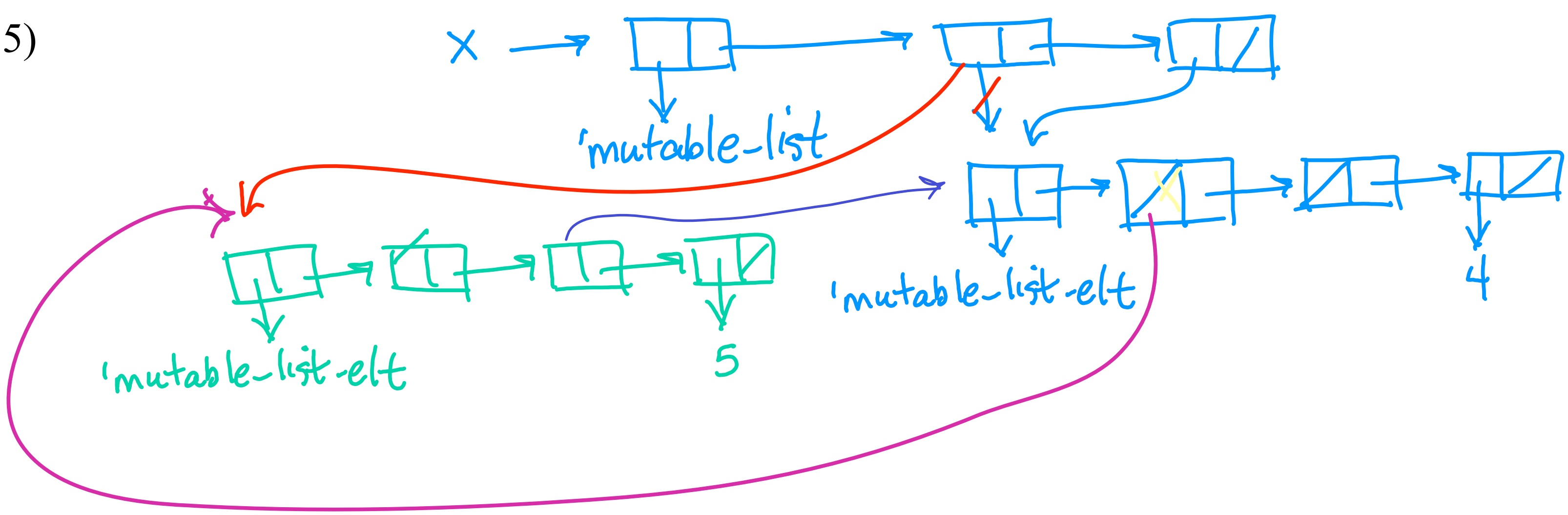
stacks and queues

We'll implement stacks and queues using the ADT, mutable-list, described in the accompanying handout. Here's an example.

```
(let*  ((e  (make-element  4))
         (x  (make-mutable-list e  e)))
x)
```



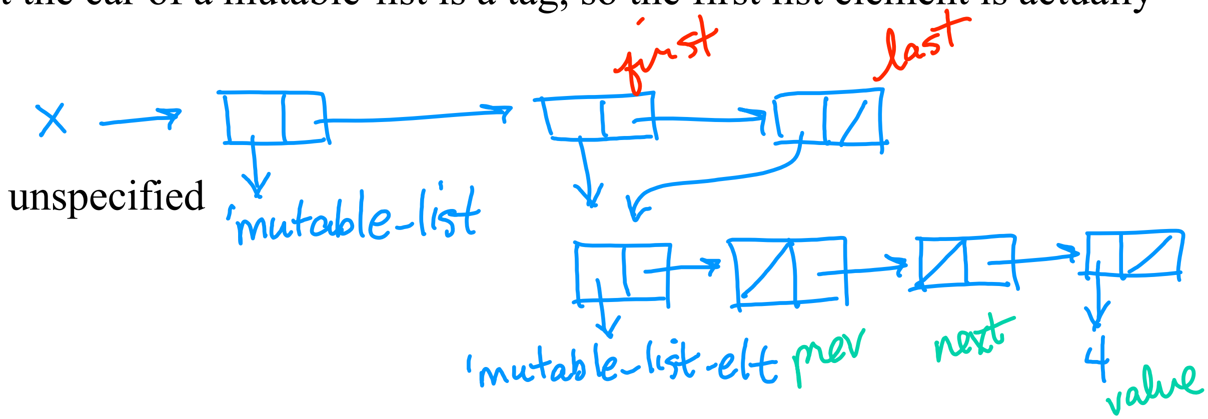

```
(add-to-front!  x  5)
```



stack and queue problems

Using the procedures for a new data type called mutable-list, provided in the accompanying handout, write the following procedures.

1. Define set-last! which modifies the first or last pointers of a mutable-list to point at the new elements. set-first! is defined for you. (Recall that the car of a mutable-list is a tag, so the first list element is actually the cadr.)




```
(define (set-first! m-l e)
;;  type:  mutable-list, <element|null>→ unspecified
   (if (mutable-list? m-l)
       (set-car! (cdr m-l) e)
       (error  "not a mutable list")))
```

```
(define (set-last! m-l  e)
;;  type:  mutable-list, <element|null>→ unspecified
(if (mutable-list? m-l)
    (set-car! (cddr m-l) e)
    (error "not a mutable list")))
```

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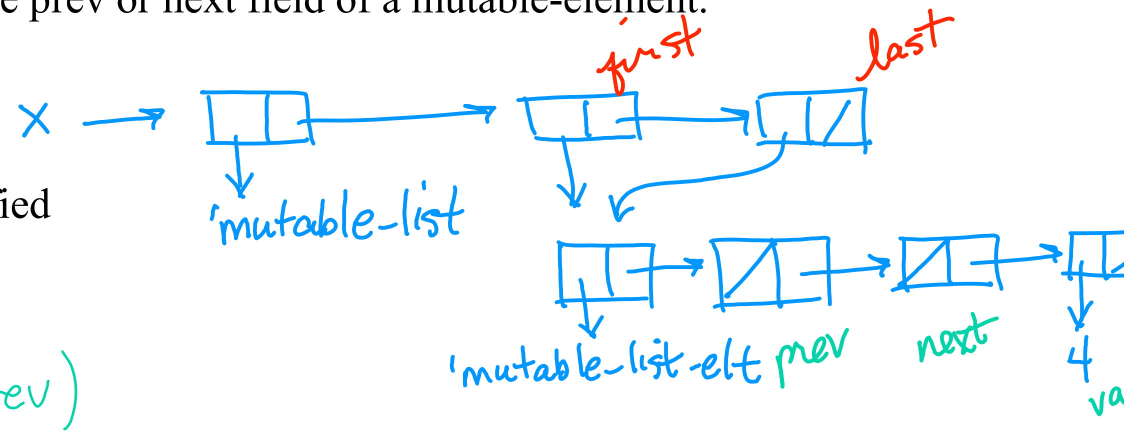
2. Define set-prev! and set-next! that change the prev or next field of a mutable-element.



(define (set-prev! element prev)
;; type: element, <element|null>➞ unspecified

```
(if (mutable-elt? element)
    (set-car! (cdr element) prev)
    (error "not mutable element")))
```

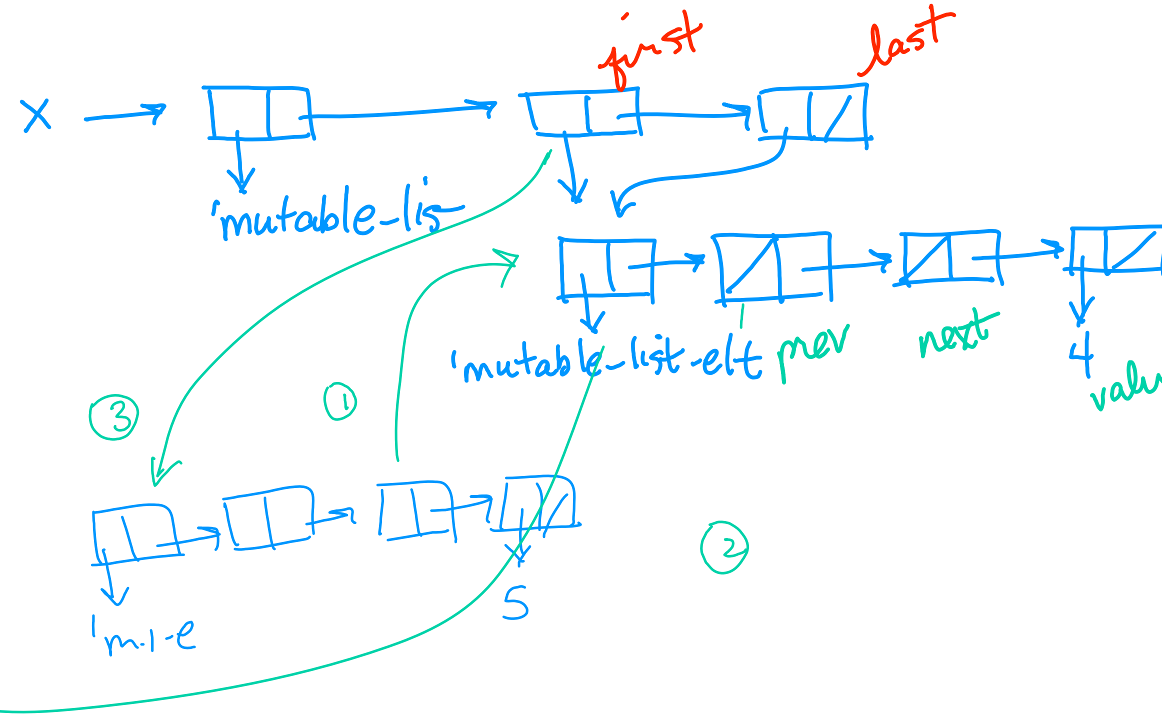
(define (set-next! element next)
;; type: mutable-list, <element|null>➞ unspecified

```
(if (mutable-elt? element)
    (set-car! (cddr element) next)
    (error "not mutable element")))
```

stack and queue problems

3a. Complete the definition for add-to-front! which takes any value and adds a new element to the front of the list containing that value. Then define add-to-back! which does the same for the back of the list.

```
(define (add-to-front! lst item)
;;  type:  mutable-list A ➔ unspecified
  (let ((e  (make-element  item)))
     (cond  ((not  (mutable-list?  lst))
                        (error "not a mutable list"))
                 ((empty-mutable-list?  lst)
                        (set-first! lst  e)
                        (set-last!  lst e))
                 (else
```

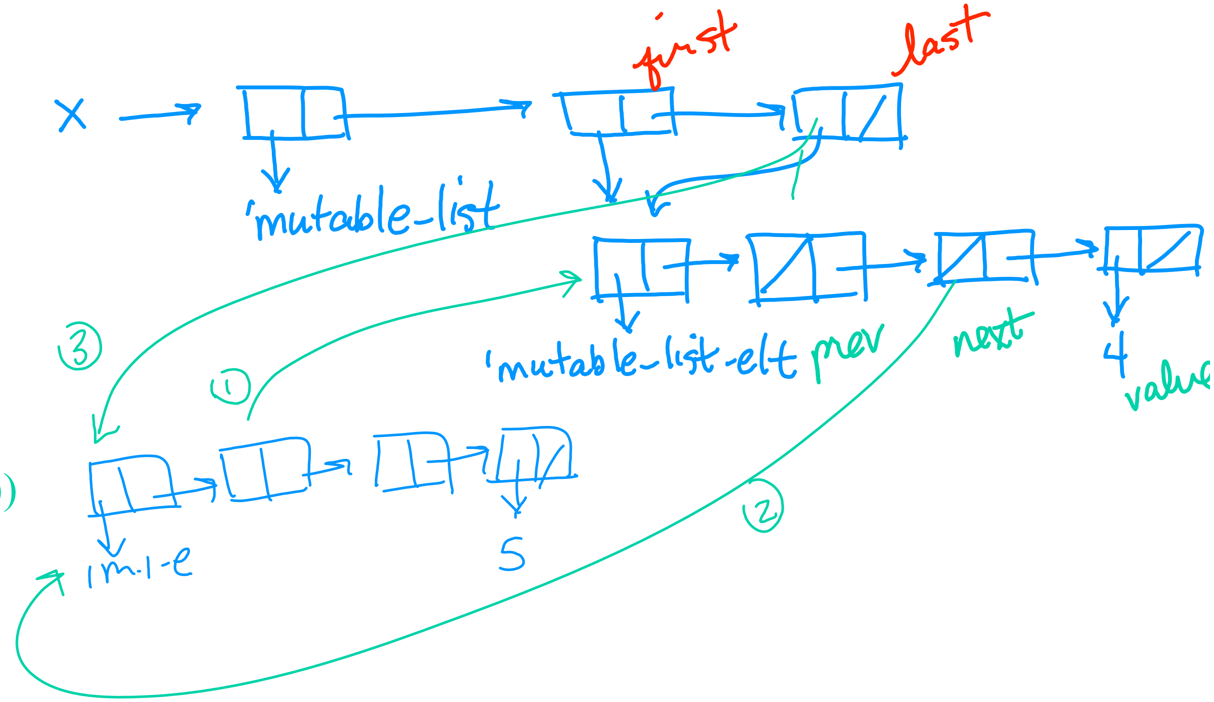



```
(set-next!  e  (first-element  lst))
(set-prev!  (first-element  lst)  e)
(set-first!  lst  e)))))
```

stack and queue problems

3b. Write add-to-back! which takes any value and adds a new element containing that value to the back of the list.

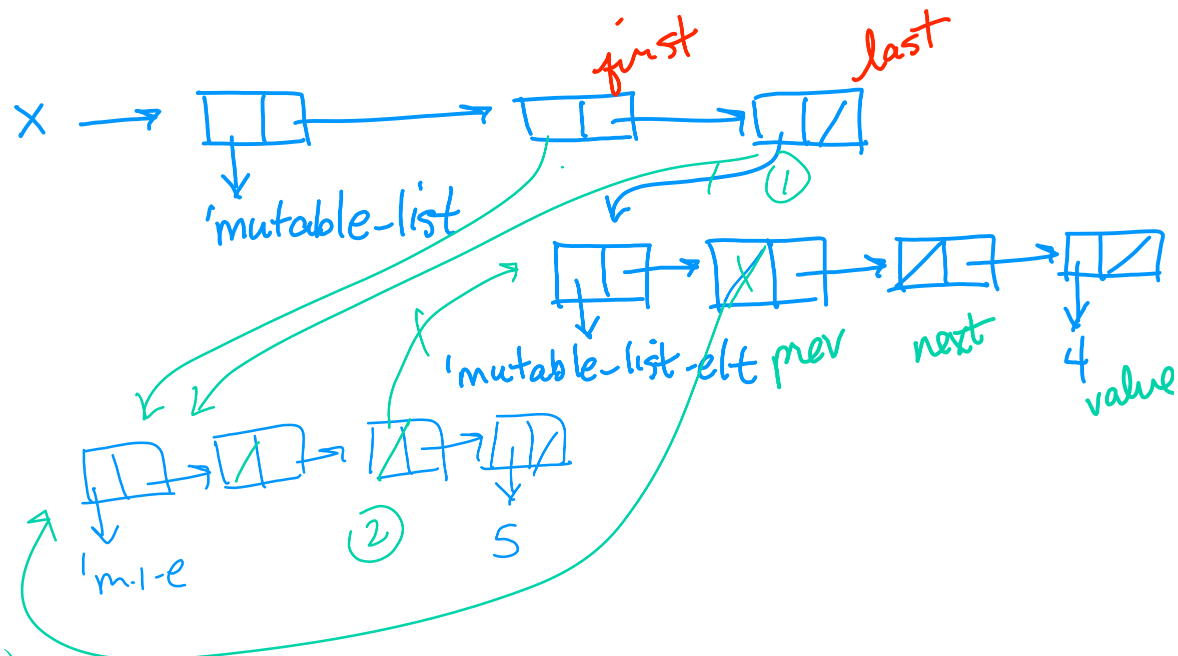
```
(define (add-to-back! lst item)
;; type: mutable-list A → unspecified
(let ((e (make-element item)))
  (cond ((not (mutable-list? lst))
             (error "not a mutable list"))
        ((empty-mutable-list? lst)
             (set-first! lst e)
             (set-last! lst e))
        (else (set-prev! e (last-element lst))
              (set-next! (last-element lst e)
              (set-last! lst e)))))
```



stack and queue problems

4a. Complete the definition for remove-from-back! which removes the last element and returns its value.

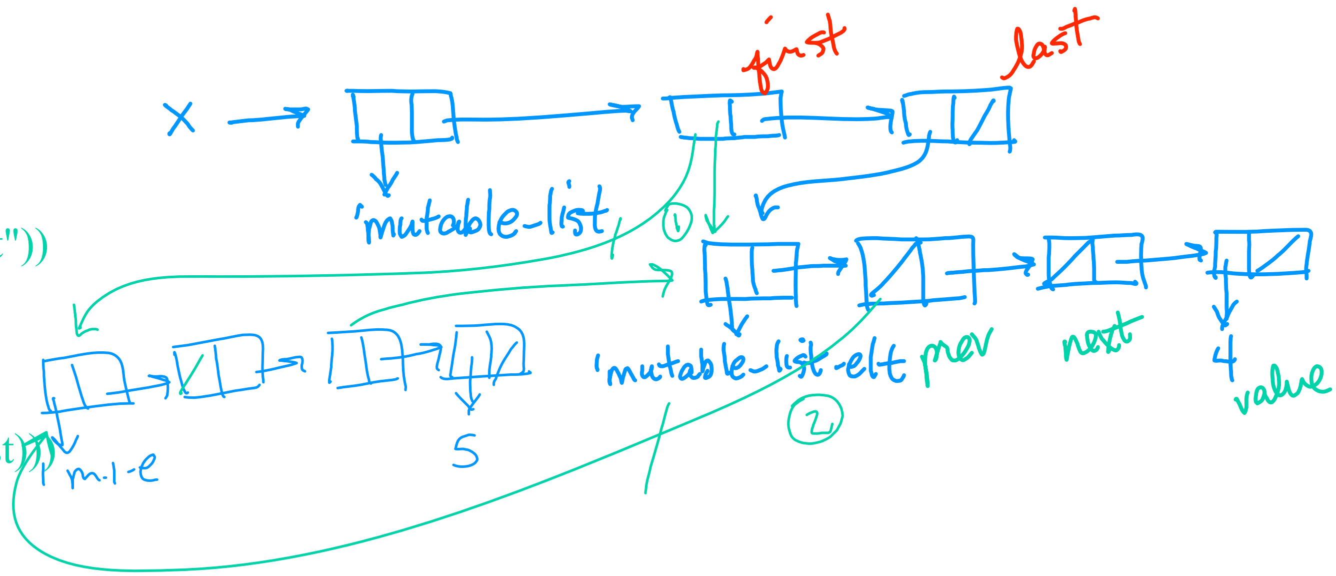
```
(define (remove-from-back! lst)
   ;; type:  mutable-list ➞ A
     (let ((e  (make-element  item)))
        (cond  ((not  (mutable-list?  lst))
                          (error "not a mutable list"))
                    ((empty-mutable-list?  lst)
                          (error "list is empty"))
                    ((single-entry?  lst)
                    (let ((e  (last-element  lst)))
                          (set-first! lst '())
                          (set-last! lst '())
                          (element-value e))
                   (else
                      (let  ((e (last-element lst)))
                         (set-last! lst (element-prev e))
                         (set-next!  (last-element lst) '())
                         (element-value e))))))
```



stack and queue problems

4b. Write remove-from-front! which removes the first element and returns its value

```
(define (remove-from-front! lst)
;;  type:  mutable-list ➞ A
(let ((e  (make-element  item)))
   (cond  ((not  (mutable-list?  lst))
                (error "not a mutable list"))
            ((empty-mutable-list?  lst)
                (error "list is empty"))
            ((single-entry?  lst)
                (let ((e  (first-element list)))
                    (set-first! lst '())
                    (set-last! lst '())
                    (element-value e)))
            (else  (let ((e (first-element lst)))
                    (set-first! lst (element-next e))
                    (set-prev! (first-element lst) '())
                   (element-value e)))))
```



stack and queue problems

5. Write push! and pop! to use the mutable list as a stack.

(define push! add-to-back!)

(define pop! remove-from-back!)

6. Write enqueue! and dequeue! to use the mutable list as a queue.

(define enqueue! add-to-back!)

(define dequeue! remove-from-front!)

stack and queue problems

7. Using either a stack or a queue (or both!) define a procedure rpn-calc that takes a simple arithmetic expression in postfix notation and evaluates it. You may assume a procedure list->mutable-list which takes a Scheme list and returns the corresponding doubly-linked list.

e.g. (rpn-calc '(1 2 +) ➔ 3
(rpn-calc '(5 1 2 + - 10 + 6 / 3 *)) ➔ 6

```
(define (list->mutable-list lst)
    (define (helper l m-l)
       (if (null? l)  m-l
           (begin (enqueue! m-l (car l))
                  (helper (cdr l) m-l))))
    (helper lst (make-mutable-list)))
```

```
(define *binary-operations*
   (list (list '+  +)
         (list '-  -)
         (list '/  /)
         (list '*  *)))
```

```
(define (rpc-calc exp)
  (let  ((stack (make-mutable-list))
         (instruction-queue  (list->mutable-list exp)))
    (define (rpn-eval atom)
      (cond  ((number?  atom)
                 (push!  stack atom))
             ((eq?  atom 'show))
                 (let ((v  (pop! stack)))
                   (display v)
                   (newline)
                   (push! stack v)))
             ((assq atom *binary-operations*)
                 (let ((op1  (assq atom *binary-operations*))
                       (a1 (pop! stack)))
                    (let ((a2 (pop! stack)))
                       (push! stack ((cadr op1) a2 a1)))))
             (else  (error "undefined operation"))))
    (define (helper)
       (if (empty-mutable-list?  instruction-queue)
           (pop! stack)
           (begin (rpn-eval (dequeue! instruction-queue))
                  (helper))))
    (helper)))
```

stack and queue problems

8. Can you define rpn-calc without using any mutating procedure?

```
(define (rpc-calc exp)
   (define (rpn-eval  stack exp)
       (cond  ((null?  exp) (car stack))
                  ((number? (car exp))
                   (rpn-eval (cons (car exp)  stack)  (cdr exp)))
                  ((eq?  (car exp 'show)
                    (display  (car  stack))
                    (newline)
                    (rpn-eval stack (cdr exp)))
                 ((assq (car exp) *binary-operations*)
                    (let ((op (cadr  (assq (car exp) *binary-operations*))))
                       (rpn-eval (cons (op (cadr stack) (car stack))  stack)
                                         (cdr exp))))
                 (else  (error "undefined operation"))))
       (rpn-eval '()  exp))
```