1. In a certain language expressions are written in infix notation. The language has binary operators and a unary prefix operator, whose precedence classes are as follows:

	binary operators	unary prefix operator	associativity
Class 1:	#	@	left
Class 2:	%	[none]	left
Class 3:	$ ^	[none]	right

Class 1 operators have ***highest*** precedence and class 3 operators have ***lowest*** precedence.

(i) Here are three expressions in this language; in each case, ***circle the operator that is applied last***:

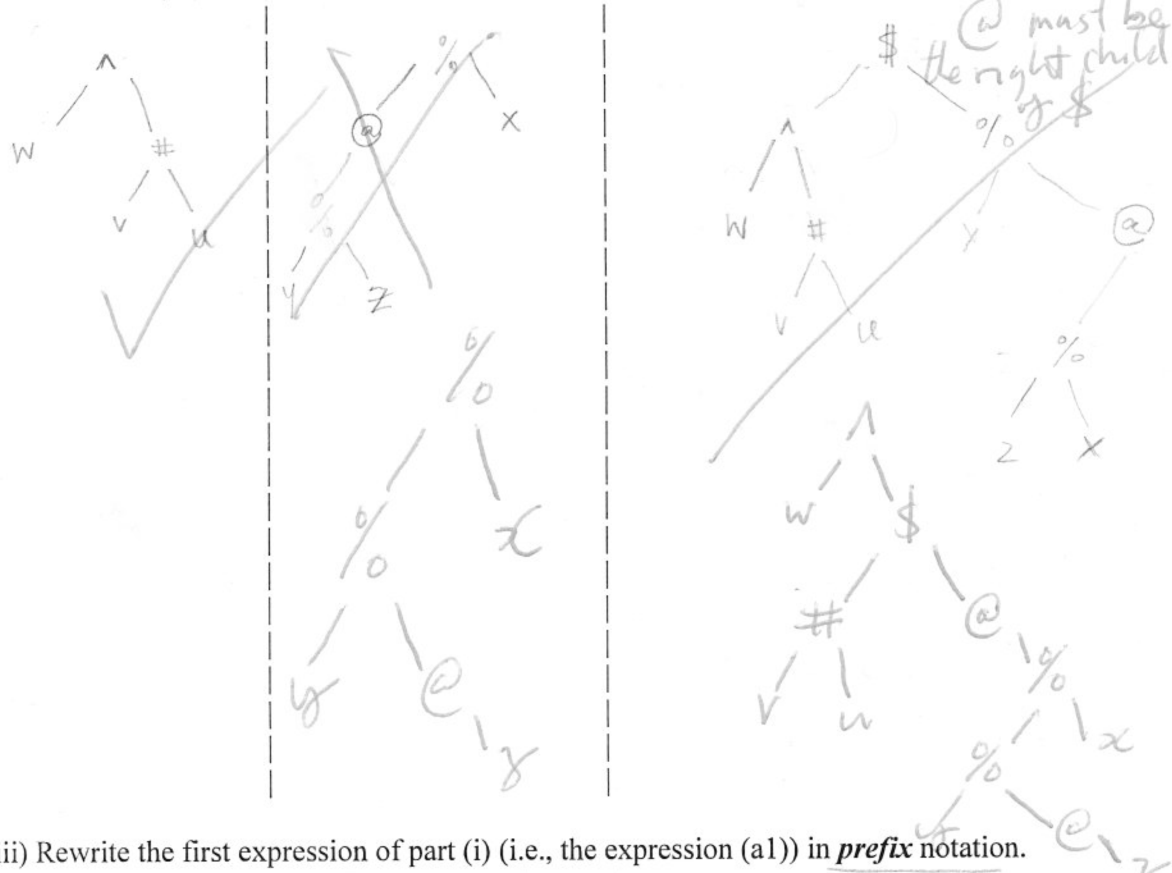
(a1) : `w ^ v # u` **[0.5 pt.]**

(a2): `y % @ z % x` **[0.5 pt.]**

(a3) : `w ^ v # u $ @ (y % @ z % x)` **[0.5 pt.]** -1/2

(ii) Draw an abstract syntax tree of ***each*** of the above expressions (a1), (a2), and (a3). **[2 pts.]** -1

Tree of (a1) | Tree of (a2) | Tree of (a3)



(iii) Rewrite the first expression of part (i) (i.e., the expression (a1)) in ***prefix*** notation.

~~# ^ w v u~~ ^ w # v u **[0.5 pt.]** -1/2

(iv) Rewrite the second expression of part (i) (i.e., the expression (a2)) in ***prefix*** notation.

~~% y z @ % x~~ % % y @ z x **[0.5 pt.]** -1/2

(v) Rewrite the third expression of part (i) (i.e., the expression (a3)) in ***prefix*** notation.

~~% z x @ y # v u ^ w~~ **[0.5 pt.]** -1/2

^ w $ # v u @ % % y @ z x

-3

2.[**1 pt.**] What is the value of the Lisp expression **(cons '(+ 3 4) '(+ 3 4))**? Circle the correct answer:

(a) **((+ 3 4) + 3 4)** (b) **(+ 3 4 + 3 4)** (c) **(7 7)**
(d) **(7 + 3 4)** (e) **((+ 3 4) (+ 3 4))**

3.[**1 pt.**] What is the value of the Lisp expression **(append '(+ 3 4) '(+ 3 4))**? Circle the correct answer:

(a) **((+ 3 4) + 3 4)** (b) **(+ 3 4 + 3 4)** (c) **(7 7)**
(d) **(7 + 3 4)** (e) **((+ 3 4) (+ 3 4))**

4.[**1 pt.**] What is the value of the Lisp expression **(list '(+ 3 4) '(+ 3 4))**? Circle the correct answer:

(a) **((+ 3 4) + 3 4)** (b) **(+ 3 4 + 3 4)** (c) **(7 7)**
(d) **(7 + 3 4)** (e) **((+ 3 4) (+ 3 4))**

5.[**4 pts.**] Suppose the Lisp variable E has been given a value as follows:

```
(setf  E
    '((-1 -2) ((90 91) 92 93 94 95 96 97 98) (9 19 29 39 49 59 69 79 89)))
```

Write a LISP expression ***which does not involve any numbers***, but which evaluates to the list

```
(-2 91 (19 29 39 49 59 69 79 89))
```

Your expression may contain the variable E and any Lisp function calls.

(cadr (car e)), (rest (third e)),

-2

(second (first (second e))

91

(19 29 39 49 59 69 79 89)

-3/4

Ans.: (~~cons~~ list (cadr (car e)) (second (first (second e))) (rest (third e)))

6.(i)[**1 pt.**] Suppose a Lisp function F is defined as follows:

```
(defun f (u)
  (let* ((x 3)        x=3
         (y (+ x u)))  y=7
    (+ x y u)))
```

Which one of the following is a ***correct*** statement about the value of the expression (F 4)? Circle the correct answer:

(a) Its value is 12. (b) Its value is 13. (c) Its value is 14. (d) Its value is 15.
(e) Its value cannot be determined without more information.

(ii)[**1 pt.**] Suppose a Lisp function G is defined as follows:

```
(defun g (u)
  (let ((x 3)        x=3
        (y (+ x u)))  y=7
    (+ x y u)))
```

Which one of the following is a ***correct*** statement about the value of the expression (G 4)? Circle the correct answer:

(a) Its value is 12. (b) Its value is 13. (c) Its value is 14. (d) Its value is 15.
(e) Its value cannot be determined without more information.

-1

-1 3/4

7.[**2 pts.**] Complete the following definition of a Lisp function SAFE-AVG that takes 2 arguments and returns the *average* (i.e., the mean) of those 2 arguments if they are numbers. But if one or both of the arguments is not a number, then the function returns the symbol BAD-ARGS. Examples:

(SAFE-AVG 2.0 6.4) => 4.2 (SAFE-AVG 3 7) => 5

(SAFE-AVG '(23.1) 47.3) => BAD-ARGS (SAFE-AVG 'ONE 'TWO) => BAD-ARGS

Hint: You may want to use the built-in predicate function NUMBERP.

(defun safe-avg (m n)

(if (and (numberp m) (numberp n))
(/ (+ m n) 2)
'BAD-ARGS))

8.[**2 pts.**] Write a Common Lisp function ~~OUR~~-REMOVE-IF such that, if f is any predicate that takes one argument and L is a list, then (remove-if f L) returns a list of all the elements of L which do ***not*** satisfy the predicate f. **Examples**:

```
(remove-if #'oddp NIL) => NIL
(remove-if #'oddp      '(3  6  5  4))  =>    (6 4)
(remove-if #'oddp    '(7  3  6  5  4))  =>    (6 4)
(remove-if #'oddp    '(2  3  6  5  4))  =>  (2 6 4)
```

funcall

Hint: A Scheme version of this function is defined in Fig. 10.5 on p. 397 of Sethi (p. 7 of the course reader). ***However, you must write your function in Common Lisp.***

(defun remove-if (f L)
(cond((endp L) NIL)
~~((cons (funcall f L) (cdr L)))))~~

−1½

9.[**2 pts.**] Complete the following definition of a Common Lisp function INSERT-D such that, if x is a real number and l is a list of real numbers **in *descending* order**, then (INSERT-D x l) returns a list of numbers, also in ***descending*** order, that is obtained by inserting x in an appropriate position in the list l. **Hint**: There are two non-base cases—x may be *greater than or equal to* the 1st element of l (as in example B below), or x may be *less than* the first element of l (as in, e.g., example D).

Examples:

```
A. (INSERT-D  8     ( )) => (8)
B. (INSERT-D  9   '(6 4 2 0 -3))  =>  (9 6 4 2 0 -3)
C. (INSERT-D  1     '(4 2 0 -3))  =>    (4 2 1 0 -3)
D. (INSERT-D  1   '(6 4 2 0 -3))  =>  (6 4 2 1 0 -3)
```

9 (8 7 6)

−1

(defun insert-d (x L)

(cond ((endp L) (list x))

((>=x (car L)) (append (list x) L))
~~((<x (car L)) (insert-D (x)))~~

−2½

10. Let `L` be a Lisp variable whose value is: `(D B B A A A A C)`
    Let `X` be a Lisp variable whose value is: `((2 B) (4 A) (1 C))`

    Notice that the value of `(cdr X)` is `((4 A) (1 C))`.

    Now write down the values of the following Lisp expressions; note that expression (e) involves `L` as well as `X`. Be sure to ***write parentheses just where they should be***: You will receive ***no credit*** if the answer is (E) and you write E, or if the answer is E and you write (E).

    (a) `(car X)` (2 B) **[0.5 pt.]** (b) `(caar X)` 2 **[0.5 pt.]** (c) `(cadar X)` B **[0.5 pt.]**

    (d) `(cons (list (+ (caar X) 1) (cadar X)) (cdr X))`

    ((3 B) (4 A) (1 C)) **[0.5 pt.]**

    (e) `(cons (list 1 (car L)) X)`

    ((1 D) (2 B) (4 A) (1 C)) **[0.5 pt.]**

11. **[2.5 pts.]** Fill in the 3 gaps in the following definition of a Lisp function COUNT-REPETITIONS such that if L is any ***nonempty*** list of atoms then (COUNT-REPETITIONS L) returns a list of pairs that indicate the number of repeated adjacent occurrences of each element of L, as shown in the following examples:

```
(COUNT-REPETITIONS '(W))  =>  ((1 W))
(COUNT-REPETITIONS   '(B B A A A A C))  =>         ((2 B) (4 A) (1 C))
(COUNT-REPETITIONS '(B B B A A A A C))  =>         ((3 B) (4 A) (1 C))
(COUNT-REPETITIONS '(D B B A A A A C))  =>   ((1 D) (2 B) (4 A) (1 C))
```

Hint: The correct answers to parts (d) and (e) of the previous question are relevant to this question!

```
(defun count-repetitions (L)
  (cond
    ((endp (cdr L)) (list (cons  1 ~~NIL~~  L)))
    (t  (let ((X (count-repetitions (cdr L))))
          (if (equal (car L) (cadr L))
              (cons (list (+ (caar x) 1)
              (cons (list 1 (car L)) X)                 )))))
```

-1½