Please write or print your solutions on A4 papers. Also, remember to write down your department, student ID, and name. The maximum score for this exercise is 200 points.

1. (10 points) Function calls.
   Consider the following C-like language. What are the results if the parameters of f are passed by value, passed by reference, passed by value/result, and passed by name?

```c
void f( int x, int y, int z )
{
    x = x + 1;
    y = z;
    z = z + 1;
}

void main()
{
    int a[2] = {10, 11};
    int i = 0;
    f( i, a[i], i );
    printf( "%d %d %d\n", i, a[0], a[1] );
}
```

2. (10 points) Function call of JAVA and reference model language.
   In C, the following code swaps the two objects.

```java
typedef struct _atom_ { int atomicNo; double mass; } Atom;

void swap( Atom *x, Atom *y )
{
    Atom *temp;
    temp = x; x = y, y = temp;
}

void main()
{
    Atom A, B;
    swap( &A, &B );
```
JAVA is a call by object or call by sharing language. It means that the values in the language are based on objects rather than primitive types. Assume the user defined structure was converted in an object in JAVA. Please write a subroutine program that swaps two objects in JAVA.

3. (10 points) Function declaration revisited.
Consider the following function declaration:
```c
double (*foo(double (*)(double, double[]), double)) (double, ...);
```

4. (10 points) Consider the following C declaration, compiled on a 32-bit Pentium machine:
```c
struct {
    int n;
    char c;
} A[10][10];
```

If the address of A[0][0] is 1000 (decimal), what is the address of A[3][7]? and A[5][9]? (Remember the address/memory alignment is at 32 bit)

5. Write a Common LISP function called palindrome that takes a list as input and returns 't' is the list is a palindrome, and 'nil' otherwise.

(a) (10 points) Examples of the function in operation are shown below:
```lisp
> (palindrome '(a b b a))
t
> (palindrome '(a b c b a))
t
> (palindrome '(a b c))
nil
> (palindrome '(a (d e) b (d e) a))
t
> (palindrome '(a (d e) b (e d) a))
nil
```

(b) (10 points) (Source: palin2_SID.l) The third example (palindrome '(a (d e) b (d e) a)) is considered a palindrome in our previous exercise. We now redefine the palindrome to include sublists, i.e., (palindrome '(a (d e) b (e d) a)) is a palindrome. The atoms within the list should also be reversed and compared.

6. (10 points) Write a Common LISP function called flatten that takes a list that may have embedded lists, and returns a flattened version of it (i.e., a list whose elements are only atoms and empty lists have been removed). Examples of the function in operation:
```lisp
> (flatten '(a b c d))
(a b c d)
> (flatten '(a () b (c d)))
```
7. Write a program in ML or F#. Define a datatype gene which consists of the elements A|T|C|G. Now, from a constructed list of genes, perform the following operations.

(a) (10 points) Find the base paring of a strand (A$\leftrightarrow$T, C$\leftrightarrow$G), for example

(b) (10 points) Count the number of specific genes in the list, for example:
- count(x,A);
- val it = 8 : int
- count(x,G);
- val it = 3 : int

(c) (10 points) Print the statistics for the gene sequence, for example:
- statistics(x);
- val it = [(A,8),(T,6),(C,5),(G,3)] : (gene * int) list

(d) (10 points) Write a ML function compare to compare two DNA strands. The lexical order is A < G < T < C. Return the strand with larger order. For example:
- val x = [A,T,A,C];
- val y = [A,G,C];
- val z = [A,C,G];
- val q = [C,T,A,G];
- val it = [A,A,C] : gene list
- compare(x,y);
- val it = [A,T,A,C] : gene list
- compare(x,z);
- val it = [A,C,A] : gene list
- compare(y,z);
- val it = [A,C,A] : gene list
 Hin: You may require more than one function to accomplish this easier.)
8. (a) (10 points) Write a common LISP, ML, or F# program that finds possible changes for a currency given the dollar amount.
   - \( \text{val usCoins} = [25,10,5,1]; \)
   - \( \text{change(usCoins, 57);} \)
   \( \text{val it} = [25,25,5,1,1] : \text{int list} \)

   (b) (10 points) Modify the above program to find all possible ways of making change. Add a function to count the number of possibilities. - \( \text{val usCoins} = [25,10,5,1]; \)
   - \( \text{allChange([],usCoins,12);} \)
   \( \text{val it} = [[[1,1,10],[1,1,5,5],[1,1,1,1,1,1,1,5],[1,1,1,1,1,1,1,1,1,1,1,1]]} : \text{int list list} \)

9. Write a arbitrary datatype binary tree data struture in SML which supports the following operations: (*Note: Test data may be either one of the following - integers, strings, lists, tuples, floats, or complex numbers)

   (a) (5 points) Prints the binary tree in preorder lists.
   \( \text{val t = Node (Node (Empty,"Drive",Node #),"Test",Node (Node #,"Kick",Empty)) : string btree} \)
   - \( \text{prefix(t);} \)
   \( \text{val it} = ["Test","Drive","Car","Kick","Right","Hand","Foot"] : \text{string list} \)

   (b) (5 points) Prints the binary tree in inorder lists.
   - \( \text{innfix(t);} \)
   \( \text{val it} = ["Drive","Car","Test","Hand","Right","Foot","Kick"] : \text{string list} \)

   (c) (5 points) Prints the binary tree in posorder lists.
   - \( \text{postfix(t);} \)
   \( \text{val it} = ["Car","Drive","Hand","Foot","Right","Kick","Test"] : \text{string list} \)

   (d) (5 points) Count the number of nodes in the arbitrary binary tree.
   - \( \text{countNode(t);} \)
   \( \text{val it} = 7 : \text{int} \)

   (e) (5 points) Count the number of leaf nodes in the arbitrary binary tree.
   - \( \text{countLeaf(t);} \)
   \( \text{val it} = 3 : \text{int} \)

   (f) (5 points) Find a certain element in the binary tree.
   - \( \text{findNode("!!",t);} \)
   \( \text{val it} = \text{false} : \text{bool} \)
10. (20 points) Determine the prime factors of a given positive integer. Construct a flat list containing the prime factors in ascending order.

- `factors 315;`
  val it = [3; 3; 5; 7] : int list

11. (20 points) Implement the 8-queens problem in ML. This is a classical problem in computer science. The objective is to place eight queens on a chessboard so that no two queens are attacking each other; i.e., no two queens are in the same row, the same column, or on the same diagonal.

   **Hint:** Represent the positions of the queens as a list of numbers 1...N. **Example:** [4;2;7;3;6;8;5;1] means that the queen in the first column is in row 4, the queen in the second column is in row 2, etc. Use the generate-and-test paradigm.

   - `queens_positions 4;`
     val it = [[3; 1; 4; 2]; [2; 4; 1; 3]] : int list list
   - `List.length (queens_positions 8);`
     val it = 92 : int