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Final

There are three problems for a total of 99 points. Show all your work, partial credit will be awarded. When there is not enough room on the test page itself, write in the provided blue books and write and sign your name on each one. No notes, no collaboration.

Name: _____

Problem	Credit
1	
2	
3	
Total	

1. Finish writing the following Quicksort program:

```
type MyArray = array [0..1000] of integer ;

procedure QuickSort( var A : MyArray ; i,j : integer ) ;
var M: integer ; (* index of split *)
    i_, j_: integer ; (* helper indices *)
    s : integer ; (* splitter value *)
begin
   if i<j then begin
      (* Split A[i..j], setting M such that:
         1) i <= M <= j
         2) A[k] <= A[M], for all i <= k < M
         3) A[M] <= A[k], for all M < k <= j
       *)
```

```
      (* recurse *)
      QuickSort( A, i, M-1 ) ;
      QuickSort( A, M+1, j ) ;
   end  (* if statment *)
end ; (* procedure QuickSort *)
```

2. Finish writing the following tree insert program:

```
type tree = ^tree_rec
     tree_rec = record
                   left, right : tree ;
                   data : integer ;
                   end ;

procedure tree_insert( var t : Tree ; v : integer ) ;
begin
   if (t<>NIL) then begin
```

```
   end (* if *) else begin
      new(t) ;
      t^.left := NIL ;
      t^.right := NIL ;
      t^.data := v ;
   end (* else *)
end ; (* procedure tree_insert *)
```

3. Rewrite the following function, using only *recursion* (no loop constructs):

```
function sum(N) : integer ;
var i : integer ;
begin
  {Precondition: N is any integer.}
  i := 0 ;
  repeat
    i := i + 1
  until (i*i) > N ;
  sum := i
end ;
```