Computers in Engineering Pseudocode and C Language Review

Pseudocode

- Pseudocode is an artificial and informal language that helps you develop algorithms.
- Pseudocode is similar to everyday English; it is convenient and user friendly although it is not an actual computer programming language.
- Pseudocode programs are not executed on computers. Rather, they merely help you "think out" a program before attempting to write it in a programming language such as C.
- Pseudocode consists purely of characters, so you may conveniently type pseudocode programs into a computer using an editor program.

Pseudocode

- Carefully prepared pseudocode programs may be converted easily to corresponding C programs.
- Pseudocode consists only of action statements- those that are executed when the program has been converted from pseudocode to C and is run in C. Definitions are not executable statements. They are messages to the compiler.
- Each variable should be listed and the purpose of each should be briefly mentioned at the beginning of the pseudocode program.

Guide for Pseudocode

1. State your name
2. State the date
3. State the name of the subroutine.
4. Give a brief description of the function of the subroutine/program.
5. State the names of the input variables, their types, and give a brief description for each.
6. State the names of the output variables, their types, and give a brief description for each.
7. Give a list of instructions with enough detail that someone can translate the pseudocode into a computer language such as C, C++, Java, etc. Note, your pseudocode should paraphrase your algorithm and not look identical to C code.
8. Your pseudocode should be indented just like when you write your program. You should use {} or if/else/endif (for/endfor, while/endwhile, etc.) syntax to denote the start and end of blocks of statements.

Example Pseudocode

```
1.  Programmer: Gary E. Christensen
2.  Date: 8/20/06
3.  Name: print_matrix
4.  Function: Print matrix nicely to screen.
5.  Input: a[] = single subscripted int array of size arow * acol = matrix to be printed.
6.        arow = int = number of rows of matrix a.
7.        acol = int = number of columns of matrix a.
8.        MAXSIZE = global constant that specifies the maximum size of the array
9.  Output: matrix a[] printed to the screen.
10. Algorithm:

11. // Check for error conditions
12. if (arow <= 0) or (acol <= 0) then print error message and return endif
13. if (arow * acol > MAXSIZE) then print error message and return endif

14. // Print the matrix
15. k = 0
16. for i = 0 to arow - 1
17.    print bar '|'
18.    for j = 0 to acol - 1
19.       print a[k] right justified
20.       k = k + 1
21.    endfor
22.    print bar '|' followed by a newline
23. endfor
```

Documentation

- The main program and each subroutine must be documented.

```
/*****************************************************************
 *                                                               *
 * Programmer: <Your name goes here>                             *
 * Date: <Today's date>                                          *
 * Name: <function name goes here>                               *
 * Function: <Description of what the function does goes here>   *
 * Algorithm: <Describe how the function works>                  *
 * Input: <Name each input variable to the function on a separate *
 *      line and give a description of what it is>               *
 * Output: <Name each output variable on a separate line and     *
 *      give a description of what it is>                        *
 *                                                               *
 *****************************************************************/
```

Example Documentation

```
/*****************************************************************
 *                                                               *
 * Programmer: Gary Christensen                                  *
 * Date: 2/17/04                                                 *
 * Name: quicksort                                               *
 * Function: This function sorts an array of integers from       *
 *     smallest to largest value.                                *
 * Algorithm: This subroutine sorts a list of integers using     *
 *     recursion. The first element of the list is moved to      *
 *     its final position in the list and a sublist of numbers   *
 *     less than this number and a sublist of numbers greater    *
 *     than this number is created. Each sublist is then         *
 *     sorted by passing it to quicksort again. The              *
 *     termination condition for the recursion are as            *
 *     follows: A one element list is sorted by definition and   *
 *     is returned.                                              *
 * Input: ListOfInts - a pointer to an array of integers to be   *
 *     sorted.                                                   *
 *     size - the number of integers in the list to be sorted.   *
 * Output: ListOfInts - a pointer to an array of sorted integers *
 *                                                               *
 *****************************************************************/
```

If statement

Use & to read integer into variable

```
scanf("%d",&x);
if ((x < 0)||(x>5)){
    printf("Please enter an integer between 0 and 5.\n");
    printf("Try again\n");
    scanf("%d",&x);
}
```

Logical OR Operator

```
if (score >= 60){
  printf("You Passed\n);
}else{
  printf("You Failed\n");
};
```

Logical AND Operator

Logical NOT Equal Operator

Logical Expressions

`((x <= 5)&&(x >= 0))` and `(y != 5)` are examples of ***logical expressions***.

Relational Operators

==	Equality (don't confuse with the assignment operator, =)
!=	not equal
>	greater than
<	less than
>=	greater than or equal
<=	less than or equal

Compound Conditions

- Logical Operators:

&&	Logical And
||	Logical Or
!	Not (complement)

```
if ((score > 100) || (score < 0)){
  printf("Score is invalid\n");
}

if (!((score <= 100) && (score >= 0))){
  printf("Score is invalid\n");
}
```

If-else statement

```
.
.
.
if (score == 100)
  printf("Your grade is an A+\n);
else if (score >= 95)
       printf("Your grade is an A\n");
     else if (score >= 90)
            printf("Your grade is an A-\n");
          else printf("Your grade is lower than an A-\n");
.
.
.
```

The Switch Statement

- **Multiple-selection structure**
- **Good for algorithms containing a series of decisions**
  - **– Every constant integral value tested**
  - **– Different actions for each value**
- **Consists of**
  - **case labels and default case**

Example program to count number of A, B, and C grades

```
/* Counting A, B, and C grades */
#include <stdio.h>
int main() {
  char grade;
  int aCount =0, bCount = 0, cCount=0;

  printf("Enter the letter grades A, B, or C. ");
  printf("Enter the 'return' character to end.\n");
  scanf("%c",&grade);
```

(continued on next slide)

```
while (grade != '\n') {

    switch(grade) {
      case 'a':
      case 'A': ++aCount;
                break; /* denotes end of this case */
      case 'B': ++bCount;
                break;
      case 'C': ++cCount;
                break;
      default: /* catch all other characters */
               printf("Incorrect input.\n");
    } /* end of switch */

    scanf("%c",&grade);
  } /* end of while */

  /* PRINT TOTALS HERE */
  printf("Total of %d A's, %d B's %d C's\n",
                    aCount, bCount, cCount);
  return 0;
} /* end main */
```

Counts both lower and upper case A.

More about the `switch` Construct

- **`case` labels must evaluate to an integer constant**
- **All of the labels must be unique (but can be in any order)**
- **Statement-list can contain zero or more statements**
- **Control passes to next label unless there is a `break` statement.**
- `break` **exits the enclosing** `switch`

C Loop constructs

- Permit an action to be repeated multiple times
- Three loop constructs
  - while
  - do/while
  - for
- **Example (pseudo-code):**

  While there are more homework problems to do:
  work next problem and cross it off the list
  endwhile

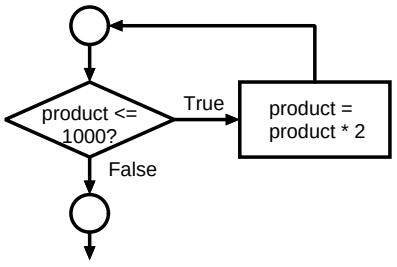
While Loop Example

- Problem: Find the first power of 2 larger than 1000
- Pseudo-code:

  Initialize value to 2
  while the value is less than 1000:
  Multiply the value by two
  endwhile

```
product = 2;
while (product <= 1000) {
   product = product * 2;
}
```

While Loop Example Flowchart



Class Average Example

- Problem statement: A class of ten students took a quiz. The grades (integers in the range 0 to 10) for this quiz are available to you. Determine the class average on the quiz.
- class average = (sum of grades / total students)
- Main algorithm:
  - input each of the grades
  - perform the averaging calculation
  - print the result

Pseudo-code Algorithm

Set total to zero
Set grade counter to one
while (grade counter is less than or equal to ten):
  Input the next grade
  Add the grade into the total
  Add one to the grade counter
endwhile
Set the class average to the total divided by ten
Print the class average

Note: This is an example of a counter-controlled loop (loop is executed a fixed number of times, controlled by a counter)

C Program For the Example

```
/* average program, counter controlled repetition */
#include <stdio.h>
int main()  {
  /* note meaningful variable names */
  int counter, grade, total, average;
  /* INITIALIZATION phase */
  total = 0;
  counter = 1;
  /* PROCESSING phase: loop for average calculations*/
  while (counter <= 10) {
     printf("Enter grade: ");
     scanf("%d", &grade);
     total = total + grade;
     counter = counter + 1;
  } /* end while */
  /* TERMINATION phase */
  average = total / 10;
  printf("Class average is %d\n", average);
  return 0;
}
```

include stdio.h for printing and reading variables

beginning of main program

Sentinel-controlled loops

- *Sentinel value*: a special input value to indicate the end of data entry
  - Also called a flag value or signal value
- The user must enter the sentinel value to indicate that all data items have been entered
- Used in cases of indefinite repetition
  - Number of data items to be processed is not known before the loop begins executing

Class Average Example Using a Sentinel (Pseudo-code)

Initialize total to zero
Initialize counter to zero
Input the first grade
while (the user has not yet entered the sentinel):
  Add this grade into the running total
  Add one to the grade counter
  Input the next grade (possibly the sentinel)
endwhile
If the counter is not equal to zero:
  Set the average to the total divided by the counter
  Print the average
else
  Print "No grades were entered"
endif

```
/* average program, sentinel-controlled repetition */
#include <stdio.h>
int main(){

  double average = 0.0; /* new data type */
  int counter = 0;
  int grade =0;
  int total = 0;
  /* INITIALIZATION phase */
  printf("Enter grade, -1 to end: ");
  scanf("%d", &grade); /*Loop to perform summation*/
  while (grade != -1) {
    total = total + grade;
    counter = counter + 1;
    printf("Enter grade, -1 to end: ");
    scanf ("%d", &grade);
  }
  /* TERMINATION PHASE */
  if (counter != 0) {
    /* Casting to avoid integer division/truncation */
    average = ((double) total) / counter;
    printf("Class average is %.2f\n", average);
  }
  else {
    printf("No grades were entered\n");
  }
  return 0; /* program ended successfully */

}
```

new data type (double)

initializers for variable declarations

type cast

precision control for format specifier

The `for` Loop Construct

- Handles some of the counter-controlled repetition details
- Example:

```
for (counter = 0; counter < 10; counter++) {
  printf("%d\n", counter);
}
```

- for loop has three parts:
  - initializer
  - condition
  - update
- Any for loop could be re-written as a while loop (counter-controlled repetition).

`for` loop versus `while` loop

```
for (expression_1; expression_2; expression_3) {
  statement;
}
```

IS THE SAME AS:

```
expression_1;
while (expression_2) {
  statement;
  expression_3;
}
```

More `for` Loop Examples

How many times does each loop run?

1. `for (j = 1; j <= 100; j++)`
2. `for (j = 100; j >= 1; j--)`
3. `for (j = 7; j <= 77; j += 7)`
4. `for (j = 20; j >= 2; j -= 2)`
5. `for (j = 2; j <= 20; j += 3)`
6. `for (j = 99; j >= 0; j -= 11)`

`do/while` Loop Construct

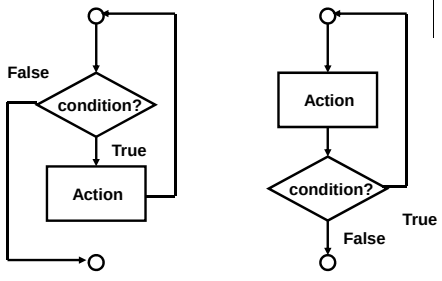
- Tests loop-continuation at the end of loop body
- Syntax:

```
do {
  statement1;
  statement2;
} while (condition);
```

- Example: What does this print?

```
int counter = 1;
do {
  printf("%d", counter);
  counter++;
} while (counter <= 10); /*Note semicolon*/
```

`do/while` Versus `while` Loop



while/do do/while

for & while statements

```
#define NUM 5

main(){
int i, a[NUM]={4, 2, 7, 3, 9};

/* Print out the elements of array a[]  */
for(i=0; i<NUM; i++){
    printf("a[%d]=%d\n",i,a[i]);
}

/* Read in integers into the array a[] */
i=0;
while (i<NUM) {
   scanf("%d",&(a[i]));
   i++;
}

/* Print out elements of array a[] */
i=0;
do {
    printf("a[%d]=%d\n",i,a[i]);
    i++;
}while(i<NUM);
}
```

Define global constants in Caps
Only have to change one place
no semi colon at end

Use & and () to read in data into array

Use do-while structure to execute command before checking condition.