CSC 270 – Survey of Programming Languages

C Lecture #3 – Arrays and Structures

Declaring Arrays

- Instead of writing:

```
int x;
```

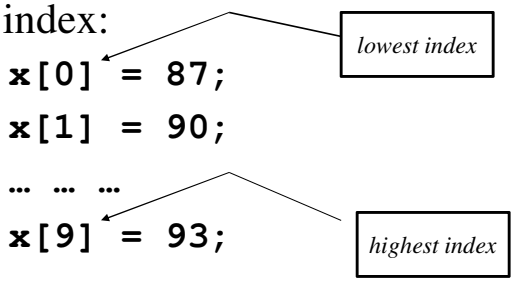
- we can write:

```
int x[10];
```

- the name x refers to the collection (or array) of integer values, which can contain up to 10 values.

Using An Array

- We can assign a value to any element in the array by specify the array by name and its index:




```
x[0] = 87;
x[1] = 90;
… … …
x[9] = 93;
```

Using An Array (continued)

- An index can be any integer or character literal, constant, variable or expression:

```
x[6] = x[5] + 4;
x[Five] = 34;
x[i+1] = x[i] + 3;
```

- This is really useful, because we do not want to have to write separate statement to assign values to each array element.

Using a Counting Loop To Set An Array

- Counting loops are really useful when manipulating arrays:

```
for (i = 0; i < 10; i++)
   printf("%d ", x[i]);
```

A Program To Find Class Average

```
#include <stdio.h>

void getgrades(int grades[]);
int calcaverage(int grades[]);
void printresults(int grades[], int mean);
char lettergrade(int score);

#define     numgrades   10
```

```
int main(void)
{
      int grades[numgrades], average;

      getgrades(grades);
      average = calcaverage(grades);
      printresults(grades, average);
      return(0);
}
```

```
void getgrades(int grades[])
{
      int count;
      for (count = 0; count < numgrades; count++) {
            printf("Enter a grade\t?");
            scanf("%d", &grades[count]);
      }
}

int calcaverage(int grades[])
{
      int count, sum = 0;
      for (count = 0; count < numgrades; count++)
            sum = sum + grades[count];
      return(sum/numgrades);
}
```

```
void printresults(int grades[], int mean)
{
      int i;

      printf("The grades are:\n");
      for (i = 0; i < 10; i++)
            printf("%d\n", grades[i]);
            printf("The average is %d", mean);
            printf(" corresponding to a grade of"
                  " %c\n", lettergrade(mean));
}
```

```
char lettergrade(int score)
{
      if (score >= 90)
            return('A');
      if (score >= 80)
            return('B');
      if (score >= 70)
            return('C');
      if (score >= 60)
            return('D');
      else
            return('F');
}
```

Selection Sorting

```
#include <stdio.h>

#define     Size  5

void sort(int x[]);

/*
 * main() - A driver for the Selection Sort
 */
int main(void)
{
      int i, a[Size];
```

```
      for (i = 0; i < Size; i++) {
            printf("Enter a[%d]\t?", i);
            scanf("%d", &a[i]);
      }
      sort(a);

      for (i = 0; i < Size; i++)
            printf("a[%d] = %d\n", i, a[i]);
      return(0);
}
```

```
/*
 * sort() - Sort an array of numbers
 */
void sort(int x[])
{
      int i, j, small, index, temp;

      /*
       * Place the smallest number in the first
       * position
       * Place the second smallest in the second
       * position and so on.
       */
      for (i = 0; i < Size -1; i++) {
            small = 32767;
            index = -1;
```

```
      /*
       * Compare each number that is not in
       * its proper place to the smallest so
       * far
       */
      for (j = i; j < Size; j++)
            if (x[j] <small) {
                  small = x[j];
                  index = j;
            }
```

```
        /*
         * Swap the ith smallest number into its
         * proper place
         */
        temp = x[i];
        x[i] = x[index];
        x[index] = temp;
        }
}
```

Multidimensional Arrays

- You can declare a two-dimensional array by writing:

```
int     x[NumRows][NumColumns];
```

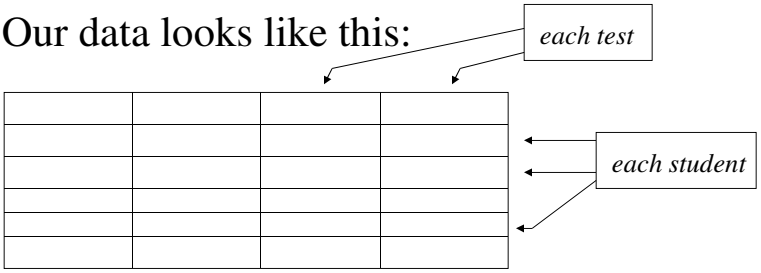
- E. g.,

```
int     x[3][6]
```

x[0][0]	x[0][1]	x[0][2]	x[0][3]	x[0][4]	x[0][5]
x[1][0]	x[1][1]	x[1][2]	x[1][3]	x[1][4]	x[1][5]
x[2][0]	x[2][1]	x[2][2]	x[2][3]	x[2][4]	x[2][5]

Example: Class Average on a Series of Exams

- Imagine that students in a class have taken four tests and their grades depends on the average score on this exam.
- Our data looks like this:



grades.c

```
#include    <stdio.h>

#define           numstudents 30
#define           numexams    4

void  readgrades(int grades[][numexams]);
void  findaverages(int averages[],
                   int grades[][numexams]);
void  writegrades(int grades[][numexams],
                   int averages[]);
```

Required; tells how many columns there are

```
/*
 * CalcAverages() -     Calculate the term
 *                      averages for a class
 *                      The average is based on
 *                      four exams
 */
int   main(void)
{
   int grades[numstudents][numexams];
   int averages[numstudents];

   /*
    * Get the grades, find the averages and
    * print them
    */
```

```
   readgrades(grades);
   findaverages(averages, grades);
   writegrades(grades, averages);

   return(0);
}
```

```
/*
 * readgrades() - Read the complete set of grades
 */
void  readgrades(int grades[][numexams])
{
  int i, j;

  // Get each students grade
  for (i = 0;  i < numstudents;  i++)     {
      //Get the next grade for this student
      for (j = 0;  j < numexams;  j++)    {
            printf("Grade on test #%d for"
                  " for student # %d\t?",
                  j, i);
            scanf("%d", &grades[i][j]);
      }
```

```
      //Skip one line for clarity
      printf("\n");
  }
}
```

```
// FindAverages() -     Find the average for each
//                      student
void  findaverages(int averages[],
                   int grades[][numexams])
{
  int i, j, sum;

  for (i = 0;  i < numstudents;  i++)     {
      sum = 0;
      for (j = 0;  j < numexams;  j++)
            sum += grades[i][j];
      averages[i] = sum/numexams;
  }
}
```

```
// WriteAverage() -     Output the grades and
//                      average for each student
void  writegrades(int grades[][numexams],
                  int averages[])
{
  int i, j;

  // Print a heading
  printf("Student Exam1\tExam2\tExam3\tExam4"
      "\tAverage\n");

  for (i = 0;  i < numstudents;  i++)     {
      // Number each line, then print the grades
      //    and the average for the enxt student
      printf("%d", i);
```

```
        for (j = 0;  j < numexams; j++)     {
              printf("\t%4d", grades[i][j]);
        }
        printf("\t%d\n", averages[i]);
    }

}
```

Limitations of **`grades.c`**

- The program has a major limitation: we must know exactly how many students there are.
- It would be better if we can safely guess our upper limit and count the exact number.

Matrices

- A matrix is a two-dimensional array of numbers, used in many types of mathematical problems.
- Adding and subtracting matrices is easy:
  - $a_{i,j} + b_{i,j} = c_{i,j}$
  - $a_{i,j} - b_{i,j} = c_{i,j}$
- Multiplying matrices is much harder:

$$c_{i,j} = \sum_{k=1}^{n} a_{i,k} \times b_{k,j}$$

multmat.c

```
#include    <stdio.h>

#define           numrows           4
#define           numcolumns        4

void  readmatrix(int matrix[][numcolumns]);
void  multmatrix(int c[][numcolumns],
                 int a[][numcolumns],
                 int b[][numcolumns]);
void  writematrix(int matrix[][numcolumns]);
```

```
/*
 * multmat() - Read and multiply two matrices
 */
int   main(void)
{
  int       a[numrows][numcolumns],
            b[numrows][numcolumns],
            c[numrows][numcolumns];

  printf("Enter matrix a\n");
  readmatrix(a);
  printf("Enter matrix b\n");
  readmatrix(b);
  multmatrix(c, a, b);
```

```
  printf("The product is:\n");
  writematrix(c);

  return(0);
}
```

```
/*
 * readmatrix() - Read in a matrix
 */
void  readmatrix(int matrix[][numcolumns])
{
  int i, j;

  for (i = 0;  i < numrows; i++)    {
      printf("Enter row #%d\t?", i+1);
      for (j = 0;  j < numcolumns;  j++)
            scanf("%d", &matrix[i][j]);
  }
}
```

```
/*
 * multmatrix() - Multiply a x b to get c
 */
void  multmatrix(int c[][numcolumns],
            int a[][numcolumns],
            int b[][numcolumns])
{
  int i, j, k;

  for (i = 0;  i < numrows; i++)
      for (j = 0;  j < numcolumns;  j++)  {
            c[i][j] = 0;
            for (k = 0;  k < numrows;  k++)
                  c[i][j] += a[i][k]*b[k][j];
      }
}
```

```
/*
 * writematrix() - Write an i x j matrix
 */
void  writematrix(int matrix[][numcolumns])
{
  int i, j;

  for (i = 0;  i < numrows;  i++)   {
      for (j = 0; j < numcolumns;  j++)
            printf("\t%d", matrix[i][j]);
      printf("\n");
  }
}
```

What is a Structure

- A structure is a heterogeneous collection of data.
- Even if the data type is the same, it may not belong in an array but in a structure.

Declaring A Structure

- A structure **containing** the rate of pay and hours worked might look like this:

```
struct {
   int rate;
   int hours;
   int gross;
} worker;
```

Declaring A Structure (continued)

- Alternatively, we can write:

```
struct {
   int rate, hours, gross;
} worker;
```

Declaring A Structure (continued)

- We can give the structure a name and then declare variables as structures of this type very easily:

```
struct workerstuff {
   int rate, hours, gross;
} ;
… …
int main(void)
{
   struct workerstuff  worker;
```

Using A Structure

- To use a field within the structure, you must specify both the structure and the field with a period "." in between:

```
scanf("%d",&worker.rate);
scanf("%d",&worker.hours);
worker.gross = worker.rate
                * worker.hours;
```

A simple payroll program

```
#include <stdio.h>

/*
 * a simple structure for payroll
 */
struct workerstuff {
      char name[20];
      float rate;
      float hours;
      float gross;
};
```

```
/*
 * payroll.c - A simple payroll program
 */
int main(void)
{
      struct workerstuff worker;
      printf("What is the worker\'s rate per "
            "hour?\t");
      scanf("%f", &worker.rate);

      printf("How many hours did the worker work "
            "last week?\t");
      scanf("%f", &worker.hours);
```

```
        printf("What is the worker\'s name?\t");
        scanf("%s", &worker.name);
        printf("%s worked for out %3.1f hours at $"
               "%4.2f per hour.\n",
               worker.name, worker.hours, worker.rate);

        return(0);
}
```

Structures Containing Arrays

- A structure can have an array as a field within it. Examples of this include character strings.
- Our Dean's List program could use this to include the grades that comprised our students' g.p.a.

typedef

- There are times when it is useful to define one's own data types. You can do this with the **typedef** statement.
- Syntax:

```
typedef     DataType DataTypeName;
```

- Examples

```
typedef int     IntegerType;
typedef int     *IntPtr;
```

->

- If we are working with a pointer to a structure and we wish to reference one of the fields, we can write:

```
*(myStructPtr.myField)
```

or

```
myStructPtr -> myField
```

- This second form is consider far better form.

avggrade.cpp

```
#include    <stdio.h>

#define           namelen           15
#define           numexams    4

typedef     struct      {
  char      firstname[namelen], lastname[namelen];
  int exam[numexams];
} examrec;

void  readstudent(examrec *student);
float findaverage(examrec student);
void  writestudent(examrec student, float
  average);
```

```
/*
 * AvgGrade() -   Averages the grades on n exams
 */
int   main(void)
{
  examrec         student;
  float           average;

  /* Read the students name and test scores */
  readstudent(&student);

  /* Find the average */
  average = findaverage(student);
```

```
   /* Print the results */
   writestudent(student, average);
   return(0);
}
```

```
/*
 * ReadStudent() -      Read the input about the
 *                      student
 */
void  readstudent(examrec *student)
{
   int       i;
   printf("First name\t?");
   scanf("%s", student -> firstname);
   printf("Last name\t?");
   scanf("%s", student -> lastname);
```

```
  for (i = 0;  i < numexams;  i++)  {
      printf("Enter grade for exam #%d\t?",
                  i+1);
      scanf("%d", &(student->exam[i]));
  }
}
```

```
/*
 * FindAverage() -      Returns the average of n
 *                      exam scores
 */
float findaverage(examrec student)
{
  int       i, sum = 0;

  for (i = 0;  i < numexams;  i++)
      sum += student.exam[i];

  return((float) sum/numexams);
}
```

```
/*
 * WriteStudent() -     Print the data about the
 *                      student including the
 *                      average
 */
void  writestudent(examrec student, float average)
{
  int i;
  printf("%s %s scored :\n",  student.firstname,
           student.lastname);

  for  (i = 0;  i < numexams;  i++)
      printf("%d\t", student.exam[i]);

  printf("\n\twhich resulted in an average of"
           "%3.1f\n", average);
}
```