Lecture 5. Arrays

- An ***array*** is a named collection of variables all of the ***same type***

  Each variable in the collection is an ***element***

  Elements are known by their integer ***positions*** or ***indices***

  ```
  int count[11];
  ```

  defines an array named `count` that has ***11*** elements with indices ***0..10***

- Array elements are accessed by ***subscripting***

  `count[` *expression* `]`

  expression is any expression whose value is an ***integer*** between 0 and 10 inclusive

  Subscript expressions are ***variables***, a.k.a. ***lvalues***

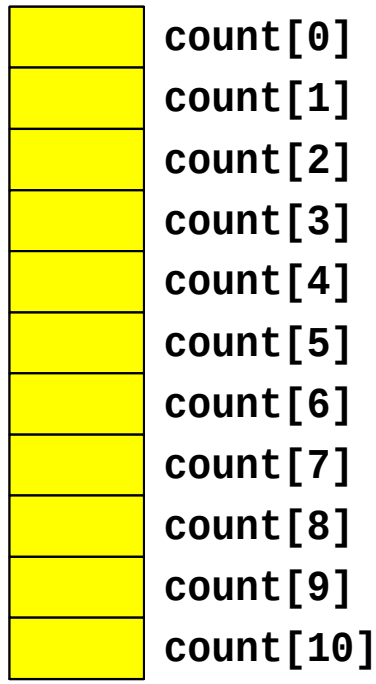
  No bounds checking — effect of out-of-bound subscripts is ***undefined***

- Array elements occupy ***successive locations*** in memory

- Array elements are ***uninitialized***; use loops to initialize them

```
int i, count[11];

for (i = 0; i < 11; i++)
    count[i] = 0;
```



Printing a Histogram

- **scores contains 115 exam scores between 0 and 100**

```
% lcc hist.c
% a.out <scores
100 **
 90 ********
 80 ************
 70 ****************************
 60 ******************
 50 **************
 40 ************
 30 *******
 20 ******
 10 *****
  0 ****
%
```

- **Use an array to hold the number of scores in each 10-point range**

```
/*
Print a histogram of scores from 0..100
in groups of 10.
*/
#include <stdio.h>

int main(void) {
    int i, counts[11], score;

    for (i = 0; i < 11; i++)
        counts[i] = 0;
    while (scanf("%d", &score) != EOF)
        counts[score/10]++;
    for (i = 10; i >= 0; i--) {
        int n = counts[i];
        printf("%3d ", 10*i);
        while (n-- > 0)
            printf("*");
        printf("\n");
    }
    return 0;
}
```

Dissecting hist.c

```
int i, counts[11], score;

for (i = 0; i < 11; i++)
    counts[i] = 0;
```

Declares `counts` and initializes each of its 11 elements to 0

```
while (scanf("%d", &score) != EOF)
    counts[score/10]++;
```

Reads the scores and increments the appropriate element of `counts`; `scanf` returns the value `EOF` at the end-of-file is reached (`EOF` is defined in `stdio.h`)

```
for (i = 10; i >= 0; i--) {
    int n = counts[i];
    printf("%3d ", 10*i);
    while (n-- > 0)
        printf("*");
    printf("\n");
}
```

Loops from `counts[10]` down to `counts[0]` printing each line of the histogram

Multidimensional Arrays

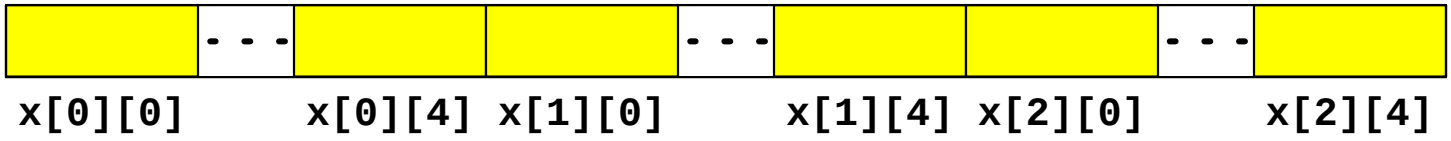
- **Multidimensional arrays have two or more indices**

```
int x[3][5];
```

defines an 2-dimensional array x that has 3×5 = 15 elements

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

- **Array *rows* occupy successive locations in memory — *row-major order***



Printing a Stem-and-Leaf Plot

- **A *stem-and-leaf plot* displays the data values themselves in a histogram**

```
% lcc stem.c
% a.out <scores
10 00
 9 97765510
 8 977655533100
 7 998777666655555444333211100
 6 9887765443332 1000
 5 44322111111000
 4 888444444311
 3 7655211
 2 865221
 1 65311
 0 8850
%
```

- **Use a 2-dimensional array to hold the number of times each score occurs**

  `counts[i][j]` is the number of times the score `10*i + j` occurs

  Each row of `counts` is a row in the stem plot

```
/*
Print a stem-and-leaf plot of scores
from 0..100.
*/
#include <stdio.h>

int main(void) {
    int i, j, counts[11][10], score;

    for (i = 0; i < 11; i++)
        for (j = 0; j < 10; j++)
            counts[i][j] = 0;
    while (scanf("%d", &score) != EOF)
        counts[score/10][score%10]++;
    for (i = 10; i >= 0; i--) {
        printf("%2d ", i);
        for (j = 9; j >= 0; j--) {
            int n = counts[i][j];
            while (n-- > 0)
                printf("%d", j);
        }
        printf("\n");
    }
    return 0;
}
```

Dissecting stem.c

```
int i, j, counts[11][10], score;

for (i = 0; i < 11; i++)
    for (j = 0; j < 10; j++)
        counts[i][j] = 0;
```

Declares `counts` as a 11-by-10 array and initializes each of its 110 elements to 0

```
counts[score/10][score%10]++;
```

Increments the element of `counts` that holds the number of times `score` occurs

```
for (i = 10; i >= 0; i--) {
    printf("%2d ", i);
    ...
    printf("\n");
}
```

Loops down the rows of `counts`, printing each 'leaf' and a new-line character

```
    for (j = 9; j >= 0; j--) {
        int n = counts[i][j];
        while (n-- > 0)
            printf("%d", j);
    }
```

Loops down the `i`th column in `counts` printing `j = score%10` for each occurrence of `score`

Passing Arrays to Functions

- **Array parameters are declared by omitting the array size**

```
void record(int score, int counts[]) {
    counts[score/10]++;
}
```

- **Arrays are passed to functions by giving just the array name**

```
int main(void) {
    int i, counts[11], score;

    for (i = 0; i < 11; i++)
        counts[i] = 0;
    while (scanf("%d", &score) != EOF)
        record(score, counts);
    for (i = 10; i >= 0; i--) {
        printf("%3d ", 10*i);
        printhist(counts[i]);
        printf("\n");
    }
    return 0;
}
```

```
void printhist(int n) {
    while (n-- > 0)
        printf("*");
}
```

- **Arrays — and only arrays — are passed in a way that simulates *call-by-reference***

  The callee *can change* elements in the caller's array argument

  An element is passed *by value* — the callee *cannot change* the caller's element

Passing Arrays to Functions, cont'd

- **Declare multidimensional array parameters by omitting only the number of rows**

```
void printstem(int counts[][10], int nrows) {
    while (--nrows >= 0) {
        int j;
        printf("%2d ", nrows);
        for (j = 9; j >= 0; j--) {
            int n = counts[nrows][j];
            while (n-- > 0)
                printf("%d", j);
        }
        printf("\n");
    }
}

int main(void) {
    int i, j, counts[11][10], score;

    for (i = 0; i < 11; i++)
        for (j = 0; j < 10; j++)
            counts[i][j] = 0;
    while (scanf("%d", &score) != EOF)
        counts[score/10][score%10]++;
    printstem(counts, 11);
    return 0;
}
```

- **Passing the number of rows, or array size, to functions helps avoid indexing bugs**