1-d Arrays

Array

- Many applications require multiple data items that have common characteristics
  - In mathematics, we often express such groups of data items in indexed form:
    - $x_1, x_2, x_3, \ldots, x_n$
- Array is a data structure which can represent a collection of data items which have the same data type (float/int/char/…)

Example: Printing Numbers in Reverse

4 numbers

3 numbers

```
int a, b, c;
scanf("%d", &a);
scanf("%d", &b);
scanf("%d", &c);
printf("%d  ", c);
printf("%d  ", b);
printf("%d  \n", a);
```

```
int a, b, c, d;
scanf("%d", &a);
scanf("%d", &b);
scanf("%d", &c);
scanf("%d", &d);
printf("%d  ", d);
printf("%d  ", c);
printf("%d  ", b);
printf("%d  \n", a);
```

The Problem

- Suppose we have 10 numbers to handle
- Or 20
- Or 100
- Where do we store the numbers ? Use 100 variables ??
- How to tackle this problem?
- Solution:
  - Use arrays

Printing in Reverse Using Arrays

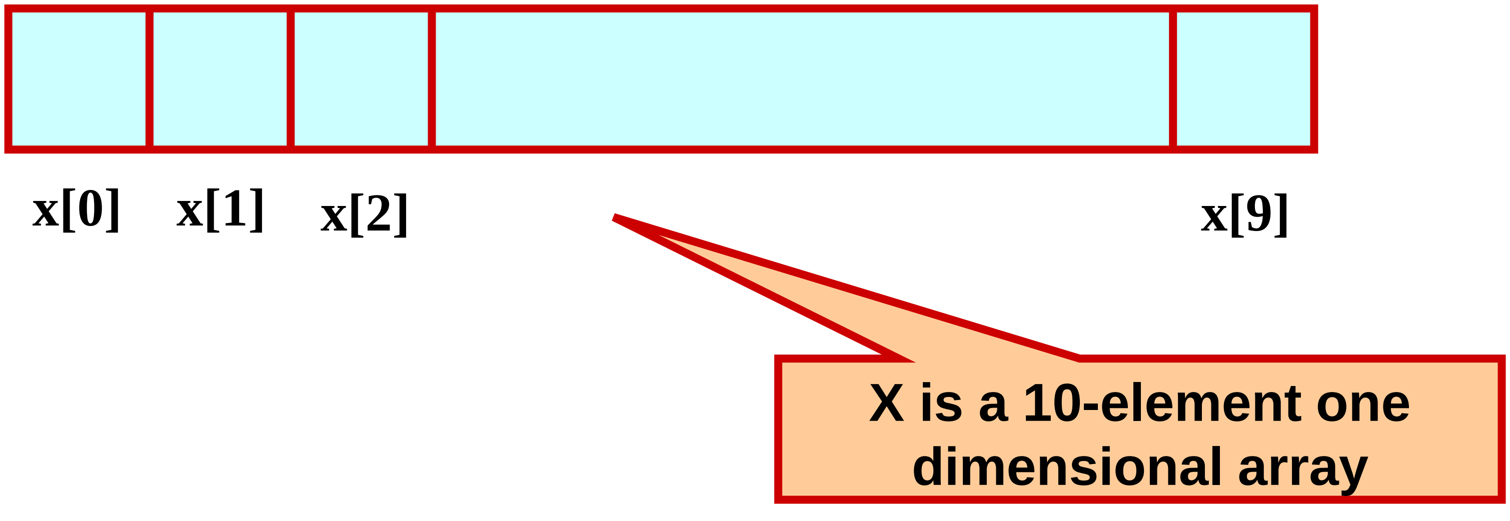
```
int main()
{
    int n, A[100], i;
    printf(“How many numbers to read? “);
    scanf(“%d”, &n);
    for (i = 0; i < n; ++i)
        scanf(“%d”, &A[i]);
    for (i = n -1; i >= 0; --i)
        printf(“%d  ”, A[i]);
    printf(“\n”);
    return 0;
}
```

Using Arrays

- All the data items constituting the group share the same name

  int x[10];

- Individual elements are accessed by specifying the index



A first example

```
int main()
{
  int i;
  int data[10];
  for (i=0; i<10; i++) data[i]= i;
  i=0;
  while (i<10)
  {
    printf("Data[%d] = %d\n", i, data[i]);
    i++;
  }
  return 0;
}
```

"data refers to a block of 10 integer variables, data[0], data[1], …, data[9]

The result

Array size should be a constant

```
int main()
{
  int i;
  int data[10];
  for (i=0; i<10; i++) data[i]= i;
  i=0;
  while (i<10)
  {
    printf("Data[%d] = %d\n", i, data[i]);
    i++;
  }
  return 0;
}
```

Output

```
Data[0] = 0
Data[1] = 1
Data[2] = 2
Data[3] = 3
Data[4] = 4
Data[5] = 5
Data[6] = 6
Data[7] = 7
Data[8] = 8
Data[9] = 9
```

Declaring Arrays

- Like variables, the arrays used in a program must be declared before they are used
- General syntax:

```
type   array-name [size];
```

  - type specifies the type of element that will be contained in the array (int, float, char, etc.)
  - size is an integer constant which indicates the maximum number of elements that can be stored inside the array

```
int   marks[5];
```

  - marks is an array that can store a maximum of 5 integers

- Examples:

```
int  x[10];
char  line[80];
float  points[150];
char  name[35];
```

- If we are not sure of the exact size of the array, we can define an array of a large size

```
int   marks[50];
```

though in a particular run we may only be using, say, 10 elements

Accessing Array Elements

- A particular element of the array can be accessed by specifying two things:
  - Name of the array
  - Index (relative position) of the element in the array
- Important to remember: In C, the index of an array starts from 0, not 1
- Example:
  - An array is defined as `int x[10];`
  - The first element of the array x can be accessed as x[0], fourth element as x[3], tenth element as x[9], etc.

Contd.

- The array index can be any expression that evaluates to an integer between 0 and n-1 where n is the maximum number of elements possible in the array

```
a[x+2] = 25;
b[3*x-y] = a[10-x] + 5;
```

- Remember that each array element is a variable in itself, and can be used anywhere a variable can be used (in expressions, assignments, conditions,…)

How is an array stored in memory?

- Starting from a given memory location, the successive array elements are allocated space in consecutive memory locations

Array A

- x: starting address of the array in memory
- k: number of bytes allocated per array element

□ A[i] ➔ is allocated memory location at address x + i*k

A Special Operator: AddressOf (&)

- Remember that each variable is stored at a memory location with an unique address
- Putting & before a variable name gives the starting address of the variable (where it is stored, not the value)
- Can be put before any variable (with no blank in between)

```
int a =10;
printf("Value of a is %d, and address of a is %d\n", a, &a);
```

Example

Output

```
int main()
{
  int i;
  int data[10];
  for(i=0; i<10; i++)
  printf("&Data[%d] = %u\n", i, &data[i]);
  return 0;
}
```

```
&Data[0] = 3221224480
&Data[1] = 3221224484
&Data[2] = 3221224488
&Data[3] = 3221224492
&Data[4] = 3221224496
&Data[5] = 3221224500
&Data[6] = 3221224504
&Data[7] = 3221224508
&Data[8] = 3221224512
&Data[9] = 3221224516
```

Initialization of Arrays

- General form:

  type array_name[size] = { list of values };

- Examples:

  int marks[5] = {72, 83, 65, 80, 76};

  char name[4] = {‘A’, ‘m’, ‘i’, ‘t’};

- The size may be omitted. In such cases the compiler automatically allocates enough space for all initialized elements

  int flag[ ] = {1, 1, 1, 0};

  char name[ ] = {‘A’, ‘m’, ‘i’, ‘t’};

How to read the elements of an array?

- By reading them one element at a time

```
for  (j=0; j<25; j++)
    scanf  ("%f", &a[j]);
```

- The ampersand (&) is necessary
- The elements can be entered all in one line or in different lines

A Warning

- In C, while accessing array elements, array bounds are not checked
- Example:

```
int   marks[5];
:
:
marks[8] = 75;
```

  - The above assignment would not necessarily cause an error
  - Rather, it may result in unpredictable program results, which are very hard to debug

Reading into an array

```
int main()  {
    const int MAX_SIZE = 100;
    int i, size;
    float marks[MAX_SIZE];
    float total;
    scanf("%d",&size);
    for (i=0, total=0; i<size; i++)
    {
        scanf("%f",&marks[i]);
        total = total + marks[i];
     }
   printf("Total = %f \n Avg = %f\n", total,
total/size);
   return 0;
}
```

Output

```
4
2.5
3.5
4.5
5
Total = 15.500000
 Avg = 3.875000
```

How to print the elements of an array?

- By printing them one element at a time

```
for  (j=0; j<25; j++)
    printf  ("\n %f", a[j]);
```

  - The elements are printed one per line

```
printf  ("\n");
for  (j=0; j<25; j++)
    printf ("  %f", a[j]);
```

  - The elements are printed all in one line (starting with a new line)

How to copy the elements of one array to another?

- By copying individual elements

```
for  (j=0; j<25; j++)
    a[j] = b[j];
```

- The element assignments will follow the rules of assignment expressions
- Destination array must have sufficient size

Example 1: Find the minimum of a set of 10 numbers

```
int main()
{
    int  a[10], i, min;

    for  (i=0; i<10; i++)
        scanf (“%d”, &a[i]);

    min = a[0];
    for  (i=1; i<10; i++)
    {
        if  (a[i] < min)
            min = a[i];
    }
    printf (“\n Minimum is %d”, min);
    return 0;
}
```

Alternate Version 1

Change only one line to change the problem size

```
const int size = 10;

int main()
{
   int  a[size], i, min;

   for  (i=0; i<size; i++)
      scanf (“%d”, &a[i]);

   min = a[0];
   for  (i=1; i<size; i++)
   {
      if  (a[i] < min)
         min = a[i];
   }
   printf (“\n Minimum is %d”, min);
   return 0;
}
```

Alternate Version 2

```
#define size 10

int main()
{
    int  a[size], i, min;

    for  (i=0; i<size; i++)
        scanf (“%d”, &a[i]);

    min = a[0];
    for  (i=1; i<size; i++)
    {
        if  (a[i] < min)
            min = a[i];
    }
    printf (“\n Minimum is %d”, min);
    return 0;
}
```

Change only one line to change the problem size

Used #define macro

#define macro

- #define X Y
- Preprocessor directive
  - The #include you have been using is also a preprocessor directive
- Compiler will first replace all occurrences of string X with string Y in the program, then compile the program
- Similar effect as read-only variables (const), but no storage allocated

Alternate Version 3

Define an array of large size and use only the required number of elements

```
int main()
{
   int  a[100], i, min, n;

   scanf (“%d”, &n);  /* Number of elements */
   for  (i=0; i<n; i++)
      scanf (“%d”, &a[i]);

   min = a[0];
   for  (i=1; i<n; i++)
   {
      if  (a[i] < min)
         min = a[i];
   }
   printf (“\n Minimum is %d”, min);
   return 0;
}
```

Example 2: Computing cgpa

Handling two arrays at the same time

```
const int  nsub = 6;

int main()
{
    int  grade_pt[nsub], cred[nsub], i, gp_sum=0,
cred_sum=0;
    double gpa;

    for  (i=0; i<nsub; i++)
        scanf ("%d %d", &grade_pt[i], &cred[i]);

    for  (i=0; i<nsub; i++)
    {
        gp_sum += grade_pt[i] * cred[i];
        cred_sum += cred[i];
    }
    gpa = ((float) gp_sum) / cred_sum;
    printf ("\n Grade point average:  is %.2lf", gpa);
    return 0;
}
```

Things you cannot do

- You cannot
  - use = to assign one array variable to another

    a = b;   /* a and b are arrays */

  - use == to directly compare array variables

    if (a = = b) ………..

  - directly scanf or printf arrays

    printf (“……”, a);

Character Arrays and Strings

char C[8] = { 'a', 'b', 'h', 'i', 'j', 'i', 't', '\0' };

- C[0] gets the value 'a', C[1] the value 'b', and so on. The last (7th) location receives the null character '\0'
- Null-terminated (last character is '\0') character arrays are also called null-terminated strings or just strings.
- Strings can be initialized in an alternative way. The last declaration is equivalent to:

```
char C[8] = "abhijit";
```

- The trailing null character is missing here. C automatically puts it at the end if you define it like this
- Note also that for individual characters, C uses single quotes, whereas for strings, it uses double quotes

Reading strings: %s format

```
int main()
{
    char name[25];
    scanf("%s", name);
    printf("Name = %s \n", name);
    return 0;
}
```

%s reads a string into a character array
given the array name or start address.
It ends the string with the special “null” character ‘\0’.

Example: Finding length of a string

```
#define SIZE 25
int main()
{
   int i, length=0;
  char name[SIZE];
  scanf("%s", name);
  printf("Name = %s \n", name);
  for (i=0; name[i]!='\0'; i++)
            length++;
  printf("Length = %d\n", length);
  return 0;
}
```

Output

```
Satyanarayana
Name = Satyanarayana
Length  = 13
```

Note that character strings read in %s format end with '\0'

Example: Counting the number of a’s

```
#define SIZE 25
int main()
{
   int i, count=0;
  char name[SIZE];
  scanf("%s", name);
  printf("Name = %s \n", name);
  for (i=0; name[i]!='\0'; i++)
      if (name[i] == 'a') count++;
  printf("Total a's = %d\n", count);
  return 0;
}
```

Output

```
Satyanarayana

Name = Satyanarayana

Total a's = 6
```

Note that character strings read in %s format end with ‘\0’

Example: Palindrome Checking

```
int main()
{
        int i, flag, count=0;
        char name[25];
        scanf("%s", name);                /* Read Name */
        for (i=0; name[i]!='\0'; i++);    /* Find Length of String */
        count=i;  flag = 0;
        /* Loop below checks for palindrome  by comparison*/
        for(i=0; i<count; i++)
            if (name[i]!=name[count-i-1])
                        flag = 1;
        if (flag ==0) printf ("%s is a Palindrome\n", name);
        else printf("%s is NOT a Palindrome\n", name);
        return 0;
}
```

Practice Problems

1. Read in an integer n (n < 25). Read n integers in an array A. Then do the following (write separate programs for each, only the reading part is common).
   1. find the sum of the absolute values of the integers.
   2. Copy the positive and negative integers in the array into two additional arrays B and C respectively. Print A, B, and C.
   3. Exchange the values of every pair of values from the start (so exchange A[0] and A[1], A[2] and A[3] and so on). If the number of elements is odd, the last value should stay the same.
2. Read in two integers n and m (n, m < 50). Read n integers in an array A. Read m integers in an array B. Then do the following (write separate programs for each, only the reading part is common).
   1. Find if there are any two elements x, y in A and an element z in B, such that x + y = z
   2. Copy in another array C all elements that are in both A and B (intersection)
   3. Copy in another array C all elements that are in either A and B (union)
   4. Copy in another array C all elements that are in A but not in B (difference)
3. Read in two null-terminated strings A and B (using %s. Assume max characters < 25 in each). Create another string C that is the concatenation of A and B (A followed by B). Print A, B, C using %s
4. Read in two null-terminated strings A and B. Check if A is lexicographically smaller, larger, or equal to B and print appropriate messages in each case.