Data and File Structures Laboratory

Review of C – Arrays, Pointers, Dynamic Memory Allocation, Structures

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What is an array?

	$A[0]$	$A[1]$	$A[2]$	...	$A[n-1]$
A	At xxxx	At xxxx+b	At xxxx+2b	...	At xxxx+(n-1)*b

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- *Length* of the array $= n$
- *Elements* of the array can be mapped to each of the n memory locations
- Elements numbered 0 through $n-1$

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```
char charArray[100], c;
charArray[i] = c; // 0 <= i <= 99
int intArray[20], i, j;
intArray[0] = i;
j = intArray[19];
```

Strings

Definition

Strings are character arrays but the end of a string is marked by the first occurrence of '\0' in the array (not the last element of the array)

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Example:

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Alphabet[3] = '\0'; // NOT '0'
/* Alphabet now holds the string "ABC" */
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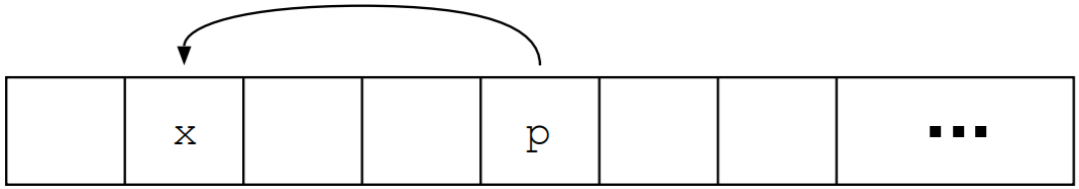
'A'	'B'	'C'	'\0'		

The fourth cell ends the string but it is not the end of the array

Pointers

- Memory = consecutively numbered storage cells (*bytes*)
- Variable can occupy one or more bytes
- *Address* of a variable = serial number of "first" byte occupied by the variable
- *Pointer* holds the address of a variable



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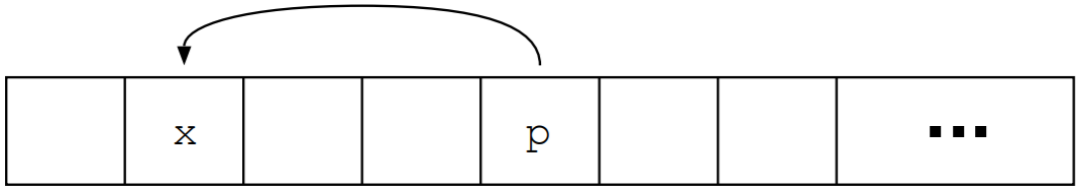

Note: A *pointer* variable (whatever be it pointing to) occupies the same number of bytes as that of an unsigned integer variable.

Operations with pointers

& – address / location operator (Address of ...)
* – dereferencing operator (Value at address ...)

```
int i, *ip; ip = &i;
*ip = 10; // same as i = 10

char c, *cp; cp = &c;
*cp = 'a'; // same as c = 'a'
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char c, *cp; cp = &c;
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```

`ip + n` – Points to the *n*-th object after what `ip` is pointing to
`ip - n` – Points to the *n*-th object before what `ip` is pointing to

Pointers and arrays

An array name is synonymous with the address of its first element. Conversely, a pointer can be regarded as an array of elements

starting from wherever it is pointing.

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```
int a[10] = {...}, *p;

p = a;          // same as p = &(a[0]);
*p = 5;         // same as a[0] = 5;
p[2] = 6;       // same as a[2] = 6;
*(a+3) = 7;     // same as a[3] = 7;
```

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Note:

`p = a; p++;` RIGHT `a = p; a++;` WRONG

The concept of base address

The following representations are basically the same

```
a[i]
i[a]
*(a+i)
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So, the base address becomes &a[0] = &(*(a+0)) = &(*a) = *(&a) = a and the value at base address is a[0] = *(a+0) = *a.

Allocating, deallocating and reallocating memory

Syntax:

```
(type *)malloc(n*sizeof(type))  // Default garbage value
(type *)calloc(n, sizeof(type)) // Default zero value
(type *)realloc(ptr, n*sizeof(type))

free(ptr)
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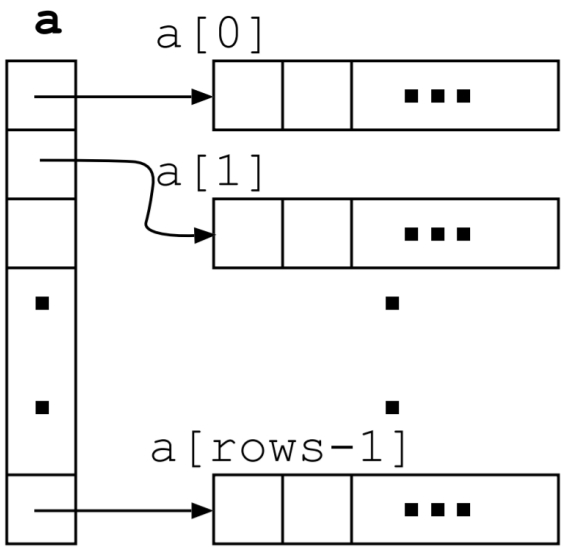
Convenient macros:

```
#define Malloc(n,type) (type *)malloc((unsigned) ((n)*sizeof(type)))
#define Realloc(loc,n,type) (type *)realloc( (char *)(loc), \
                            (unsigned) ((n)*sizeof(type)))
```

Multi-dimensional arrays

Multi-dimensional array = array of arrays = pointer to pointer

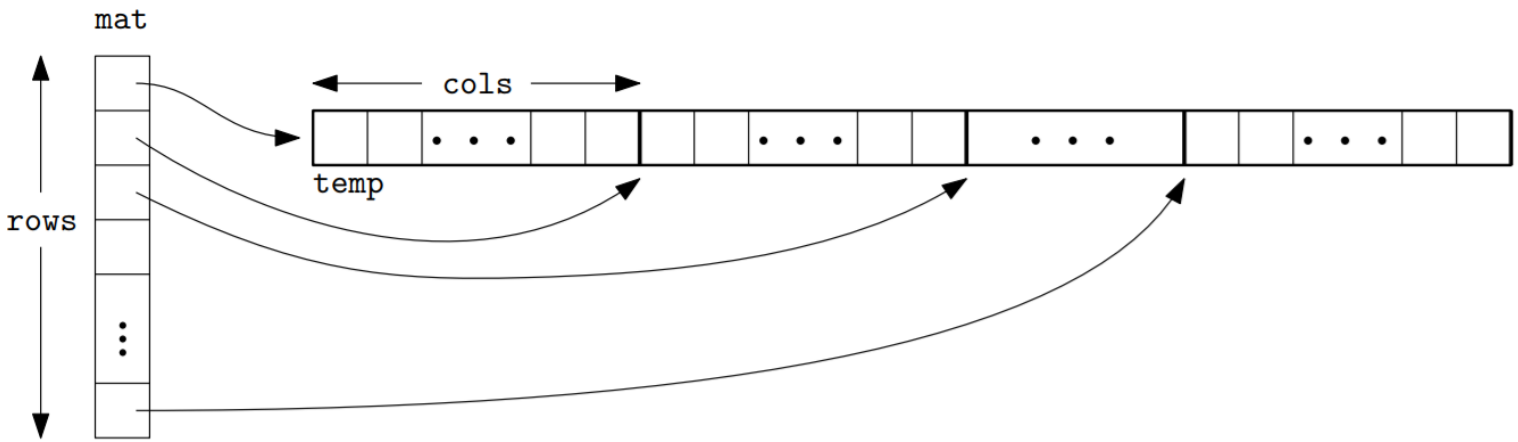
```
int **a, i;
a = (int **)malloc(rows*sizeof(int *));
for(i=0;i<rows;i++)
    a[i] = (int *)malloc(cols*sizeof(int));
```



Multi-dimensional arrays

```
for(i=0;i<rows;i++){
    free(a[i]);
}
free(a);
```

Multi-dimensional arrays




```
int ii;
int *temp;
if(NULL == (temp = (int *)malloc(rows*cols*sizeof(int))) |
    NULL == (mat = (int **)malloc(rows * sizeof(int *))))
    ERR_MESG("Out of memory");
for(ii=0;ii<rows;temp += cols,ii++)
    mat[ii] = temp;
```

Review questions

1. Suppose `s` and `t` are strings. What does the following do?
   ```
   while(*s++ = *t++);
   ```
2. What output is generated by the following code?
   ```
   for(i=0;i<=10;i++)
       printf("abcdefghijklmnop\n" + i);
   ```

Review questions — Solutions

1 String copying

```
do{
    *s = *t;
    s++; t++;
}while(*t != '\0');
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1 String copying

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    *s = *t;
    s++; t++;
}while(*t != '\0');
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do{
    *s++ = *t++;
}while(*t != '\0');
```

```
while((*s++ = *t++) != '\0');
```

Review questions — Solutions

2. Think of the problem this way:

```
p = "abcdefghijklmnop\n";
printf(p);
```

Review questions — Solutions

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```
p = "abcdefghijklmnop\n";
printf(p + 2);
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Review questions — Solutions

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p = "abcdefghijklmnop\n";
printf(p);
```

```
p = "abcdefghijklmnop\n";
printf(p + 2);
```

```
p = "abcdefghijklmnop\n";
printf(p + i);
```

Structures

Definition

A structure is a collection of one or more variables, possibly of different types, grouped together under a single name for convenient handling.

Example:

```
struct point{
    int x; // An integer field
    float y; // A floating point field
}p1, p2;

struct triangle{
    struct point a, b, c;
}t;
```

Operations on structures

- Assignment to members / fields
  `p1.x = 1; p1.y = 2.0; t.a.x = 0; t.a.y = 0.5;`
- Assignment / copying of structure variables
  `struct triangle t1, t2; ... ; t2 = t1;`
- Structures may be passed to functions, and returned by functions.

Note: Comparison operators (==, !=) do not work on structures.

Structure operations

- Initialization

```
struct point{
    int x; // An integer field
    float y; // A floating point field
}p1, p2;

struct triangle{
    struct point a, b, c;
}t = {{1, 1.0},
      {-1, 1.0},
       {1, -1.0}};
```

Typedefs

```
typedef unsigned int Length;
Length len, maxlen;
Length lengths[];
typedef char *String;
String p;                    // A single string
String myStrings[128]; // An array of strings
int strcmp(String, String);
p = (String) malloc(100);
```

Typedefs

```
typedef struct {
    int x;
    float y;
}POINT;
POINT p1, p2;

typedef struct {
    struct point a, b, c;
}TRIANGLE;
TRIANGLE t;
```

Pointers to structures

```
struct point *pp; // Old scheme (before typedef)
POINT *pp;        // New scheme (after typedef)

(*pp).x = 10; (*pp).y = 1.414; // Syntax 1
pp->x =10; pp->y = 1.414;      // Syntax 2
```

Memory allocation

```
TRIANGLE *tp;

tp = (TRIANGLE *)malloc(num_triangles*sizeof(TRIANGLE));
```

Problems – Day 3

1. Consider 2 sets of integers, A and B, are stored in arrays.
   1. Write a program to find the number of (possibly overlapping) occurrences of the sequence B in A.
   2. Write a program to find whether the multisets corresponding to A and B are equal.
2. Write a program to find the highest and second highest value in an array of n integers using less than $2n - 3$ comparisons.
3. Write a program to concatenate two strings. Find whether the concatenated result is a palindrome or not. Access the strings with pointers only.
4. Dynamically allocate memories to store a pair of matrices received from the user. If feasible, return their multiplication result without using any new matrix.

Problems – Day 3

5. Suppose complex numbers are stored using structure variables representing the real and imaginary parts separately. If x and y are two such variables then write logical conditions that evaluate to TRUE if and only if:
   - $x + y$ is an imaginary number without any real component.
   - x and y are complex conjugate.
   - Both x and y are real numbers.
6. Write a program that uses pointer to structure pointers to assign values to the pointed structure variables by taking inputs from the user.