Week 3- lecture 1

Arrays

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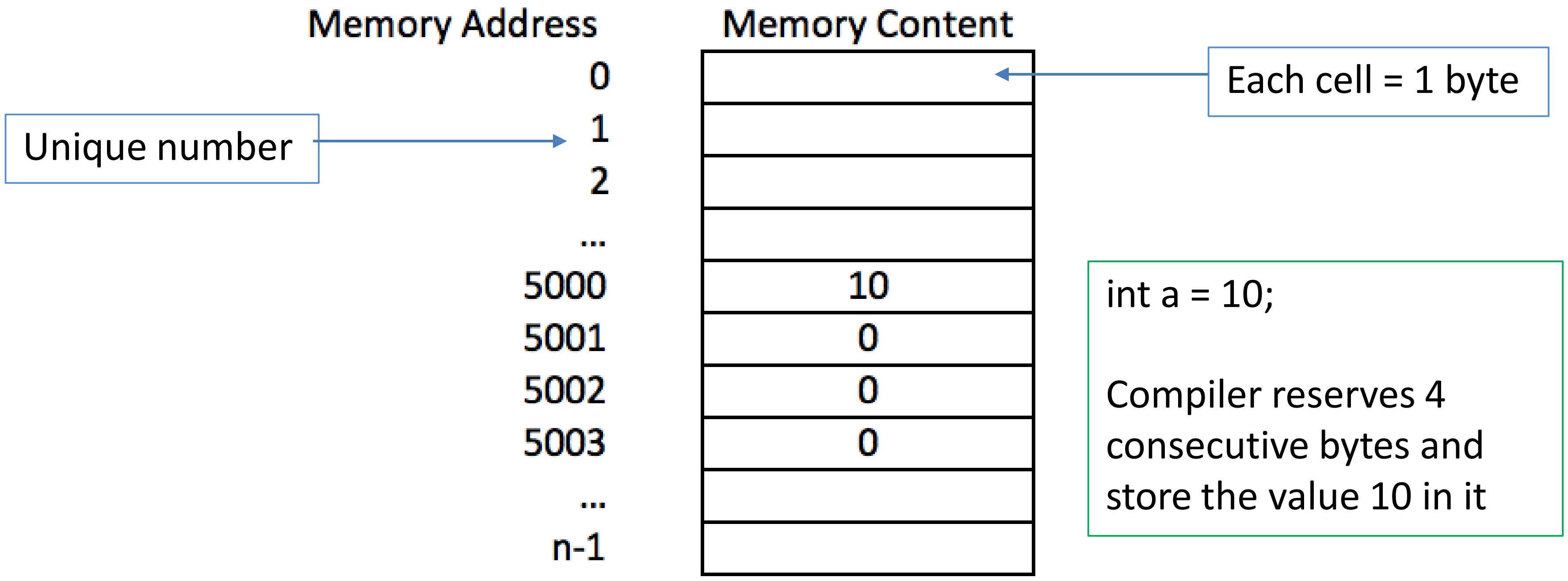
Overview

- **One dimensional array**
- Two dimensional array
- String or char array

Memory Layout

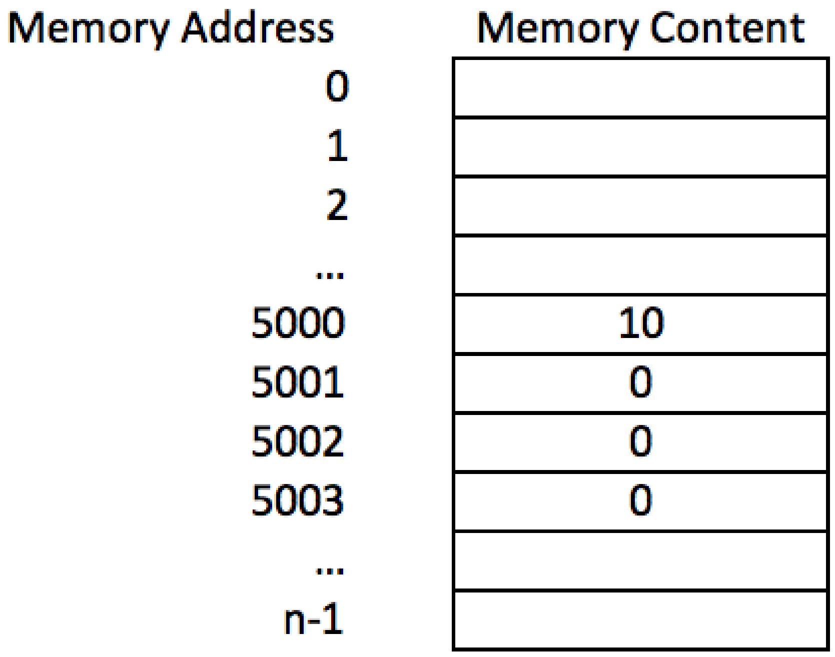


int a = 10;

Compiler reserves 4 consecutive bytes and store the value 10 in it

Array Memory Layout

- An array is a continuous block of memory to store values of the same type.



Declaring an Array

- **data_type** array_name[number_of_elements];

```
int arr[1000];
```

The number of elements remains fixed after declaring it.

```
#define SIZE 10
int arr[SIZE];
```

Values are store in consecutive memory locations. arr take 40 bytes (10 integer elements, 4 bytes each).

- Avoid useless waste of memory, declare an array with the length that is needed
- Access an array element e.g. arr[0], …, arr[9]

Index starts from zero

Array Initialisation

- int arr[4] = {10, 20, 30, 40};
- int arr[10] = {10, 20};

The values of arr[0] and arr[1] become 10 and 20 respectively, the rest of the elements are set to zero.

- int arr[] = {10, 20, 30, 40};

Creates an array with four items.

Assigning Values

- int arr[4] = {0};
  arr[0] = 1;

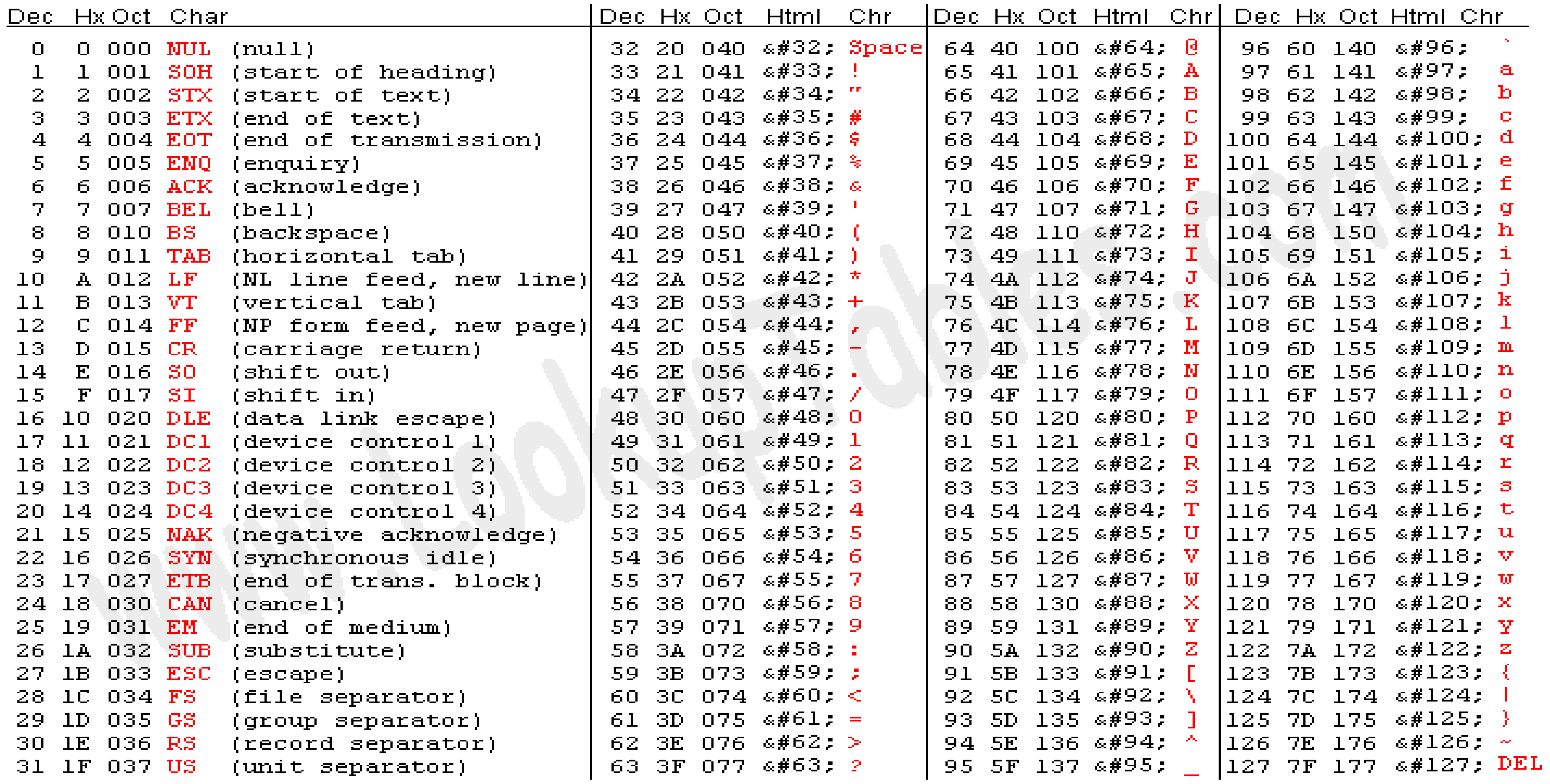
The values of arr[0], arr[1], arr[2] and arr[3] are set to zero.

- char arr[4] = {‘\0’};
  arr[4] = ‘a’;

‘\0’ is null character and is used to end a string

Array out of bound, but the compiler won’t tell you!!!

char and int in C



Dec	Hx	Oct	Char		Dec	Hx	Oct	Html	Chr	Dec	Hx	Oct	Html	Chr	Dec	Hx	Oct	Html	Chr
0	0	000	NUL	(null)	32	20	040	&#32;	Space	64	40	100	&#64;	@	96	60	140	&#96;	`
1	1	001	SOH	(start of heading)	33	21	041	&#33;	!	65	41	101	&#65;	A	97	61	141	&#97;	a
2	2	002	STX	(start of text)	34	22	042	&#34;	"	66	42	102	&#66;	B	98	62	142	&#98;	b
3	3	003	ETX	(end of text)	35	23	043	&#35;	#	67	43	103	&#67;	C	99	63	143	&#99;	c
4	4	004	EOT	(end of transmission)	36	24	044	&#36;	$	68	44	104	&#68;	D	100	64	144	&#100;	d
5	5	005	ENQ	(enquiry)	37	25	045	&#37;	%	69	45	105	&#69;	E	101	65	145	&#101;	e
6	6	006	ACK	(acknowledge)	38	26	046	&#38;	&	70	46	106	&#70;	F	102	66	146	&#102;	f
7	7	007	BEL	(bell)	39	27	047	&#39;	'	71	47	107	&#71;	G	103	67	147	&#103;	g
8	8	010	BS	(backspace)	40	28	050	&#40;	(	72	48	110	&#72;	H	104	68	150	&#104;	h
9	9	011	TAB	(horizontal tab)	41	29	051	&#41;	)	73	49	111	&#73;	I	105	69	151	&#105;	i
10	A	012	LF	(NL line feed, new line)	42	2A	052	&#42;	*	74	4A	112	&#74;	J	106	6A	152	&#106;	j
11	B	013	VT	(vertical tab)	43	2B	053	&#43;	+	75	4B	113	&#75;	K	107	6B	153	&#107;	k
12	C	014	FF	(NP form feed, new page)	44	2C	054	&#44;	,	76	4C	114	&#76;	L	108	6C	154	&#108;	l
13	D	015	CR	(carriage return)	45	2D	055	&#45;	-	77	4D	115	&#77;	M	109	6D	155	&#109;	m
14	E	016	SO	(shift out)	46	2E	056	&#46;	.	78	4E	116	&#78;	N	110	6E	156	&#110;	n
15	F	017	SI	(shift in)	47	2F	057	&#47;	/	79	4F	117	&#79;	O	111	6F	157	&#111;	o
16	10	020	DLE	(data link escape)	48	30	060	&#48;	0	80	50	120	&#80;	P	112	70	160	&#112;	p
17	11	021	DC1	(device control 1)	49	31	061	&#49;	1	81	51	121	&#81;	Q	113	71	161	&#113;	q
18	12	022	DC2	(device control 2)	50	32	062	&#50;	2	82	52	122	&#82;	R	114	72	162	&#114;	r
19	13	023	DC3	(device control 3)	51	33	063	&#51;	3	83	53	123	&#83;	S	115	73	163	&#115;	s
20	14	024	DC4	(device control 4)	52	34	064	&#52;	4	84	54	124	&#84;	T	116	74	164	&#116;	t
21	15	025	NAK	(negative acknowledge)	53	35	065	&#53;	5	85	55	125	&#85;	U	117	75	165	&#117;	u
22	16	026	SYN	(synchronous idle)	54	36	066	&#54;	6	86	56	126	&#86;	V	118	76	166	&#118;	v
23	17	027	ETB	(end of trans. block)	55	37	067	&#55;	7	87	57	127	&#87;	W	119	77	167	&#119;	w
24	18	030	CAN	(cancel)	56	38	070	&#56;	8	88	58	130	&#88;	X	120	78	170	&#120;	x
25	19	031	EM	(end of medium)	57	39	071	&#57;	9	89	59	131	&#89;	Y	121	79	171	&#121;	y
26	1A	032	SUB	(substitute)	58	3A	072	&#58;	:	90	5A	132	&#90;	Z	122	7A	172	&#122;	z
27	1B	033	ESC	(escape)	59	3B	073	&#59;	;	91	5B	133	&#91;	[	123	7B	173	&#123;	{
28	1C	034	FS	(file separator)	60	3C	074	&#60;	<	92	5C	134	&#92;	\	124	7C	174	&#124;	|
29	1D	035	GS	(group separator)	61	3D	075	&#61;	=	93	5D	135	&#93;	]	125	7D	175	&#125;	}
30	1E	036	RS	(record separator)	62	3E	076	&#62;	>	94	5E	136	&#94;	^	126	7E	176	&#126;	~
31	1F	037	US	(unit separator)	63	3F	077	&#63;	?	95	5F	137	&#95;	_	127	7F	177	&#127;	DEL

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www.LookupTables.com

char Type

- A character in the ASCII set is represented by an integer between 0 and 255
- char ch;
  ch = ‘A’;
  printf(“Char = %c and its ASCII code is %d\n”, ch, ch);
  ch++;
  printf(“Char = %c and its ASCII code is %d\n”, ch, ch);

First ch prints character A, the second ch prints ASCII value of A which is 65

First ch prints character B, the second ch prints ASCII value of B which is 66

Array Out of Bound

- C does **NOT** check if the array index you try to access is valid!

```
#include<stdio.h>
int main(void){
   int std[4];
   int i;
   std[0] = 100; //valid
   std[1] = 200; //valid
   std[2] = 300; //valid
   std[3] = 400; //valid
   std[4] = 500; //invalid(out of bounds index)
   //printing all elements
   for( i=0; i<5; i++ )
      printf("std[%d]: %d\n",i,std[i]);
   return 0;
}
```

Output:

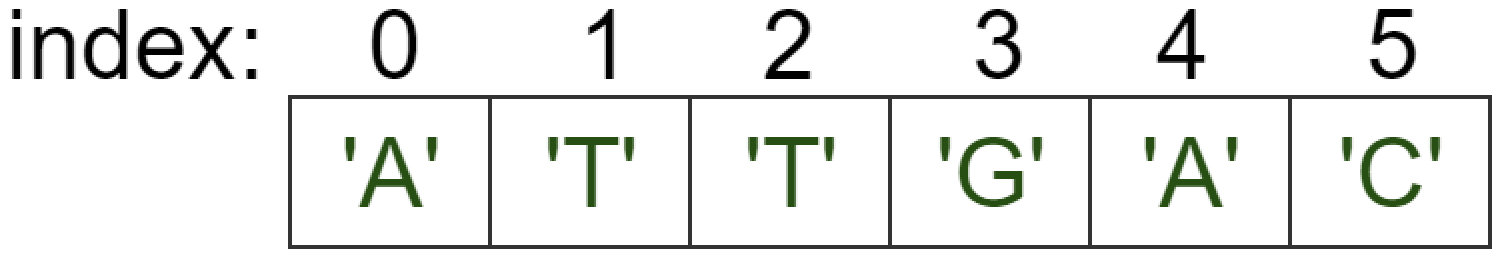
```
std[0]: 100
std[1]: 200
std[2]: 300
std[3]: 400
std[4]: 2314
```

Static and Dynamic Arrays

- Static Arrays are fixed in size.
- Size of static arrays should be determined at compile-time (before run-time).
- No need to delete static arrays, they are deleted automatically after going out of
- This reduces program execution time, particularly for programs with frequently called functions that contain large arrays.

Static and Dynamic Arrays (2)

Constructing a static array during compile time:



Static and Dynamic Arrays (3)

```
// Static arrays can be constructed like:


// Construction of array-of-integers with size 10.
int array1[10];

// Construction of array-of-characters with size 150.
char array2[150];


// Construction + Initialization of array-of-doubles with size 4
double physicalConstants[] = { 3.1415926 , 2.717 , 1.618 , 1.0 };

// Construction + Initialization of array-of-characters of size 6
char dna[] = { 'A' , 'A' , 'C' , 'T' , 'G' , 'C' };
```

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Static and Dynamic Arrays (4)

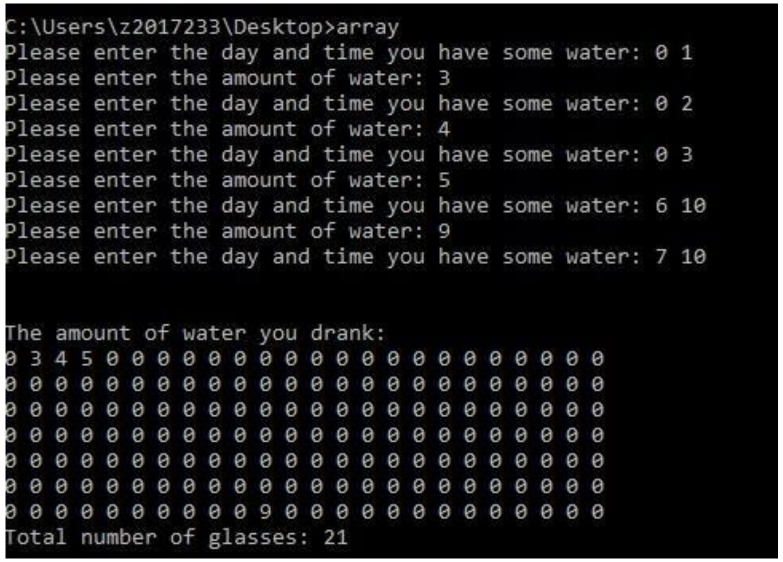
- Dynamic Arrays are allocated on heap.
- Size of dynamic arrays can be determined either at compilation or at run-time (flexible).
- You can construct very large dynamic arrays on heap, unlike static arrays.
- You need to manually delete dynamic arrays after you no longer need them.

Static and Dynamic Arrays (5)

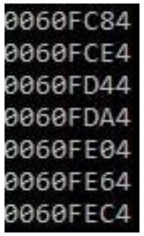
```
// Construction of dynamic arrays:


// Construction of array-of-characters with size 150000 (around 150 Mega Bytes in
memory).
char dna_chromosome11 = new char[ 150000 ];

// After we no longer need array1,
delete [] dna_chromosome;
```

Two Dimensional Array

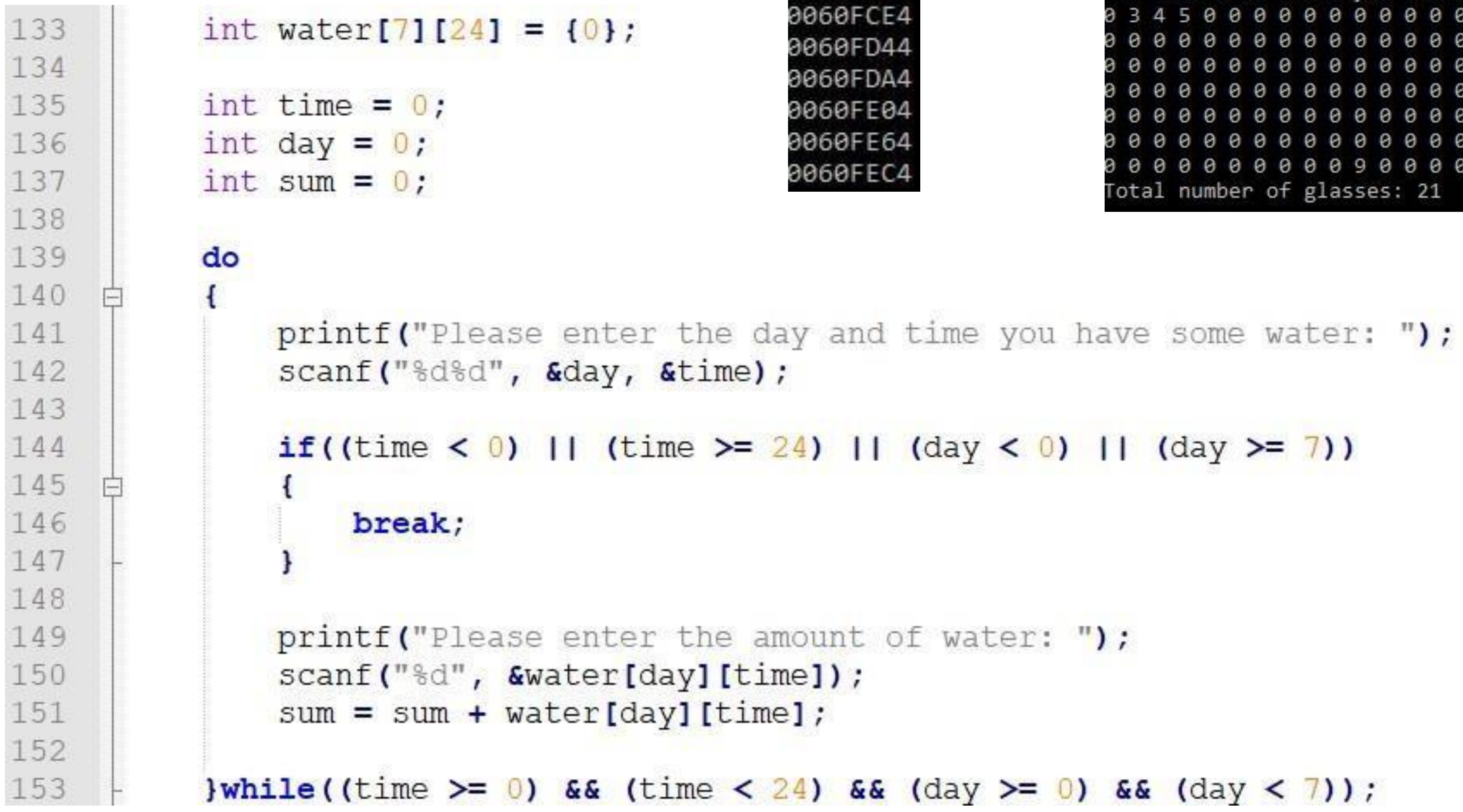
- Stored as “flat” continuous memory.



```
C:\Users\z2017233\Desktop>array
Please enter the day and time you have some water: 0 1
Please enter the amount of water: 3
Please enter the day and time you have some water: 0 2
Please enter the amount of water: 4
Please enter the day and time you have some water: 0 3
Please enter the amount of water: 5
Please enter the day and time you have some water: 6 10
Please enter the amount of water: 9
Please enter the day and time you have some water: 7 10


The amount of water you drank:
0 3 4 5 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 9 0 0 0 0 0 0 0 0 0 0 0 0 0
Total number of glasses: 21
```



```
0060FC84
0060FCE4
0060FD44
0060FDA4
0060FE04
0060FE64
0060FEC4
```

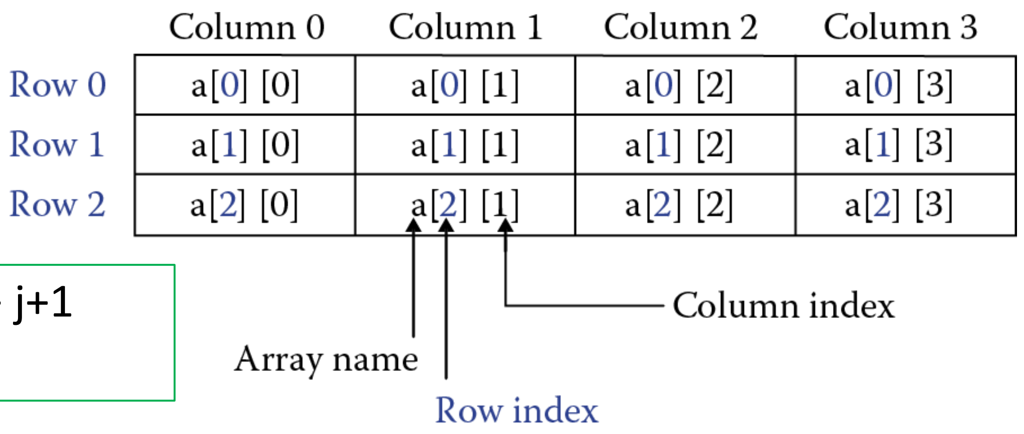


```c
    int water[7][24] = {0};

    int time = 0;
    int day = 0;
    int sum = 0;


    do
    {
        printf("Please enter the day and time you have some water: ");
        scanf("%d%d", &day, &time);

        if((time < 0) || (time >= 24) || (day < 0) || (day >= 7))
        {
            break;
        }

        printf("Please enter the amount of water: ");
        scanf("%d", &water[day][time]);
        sum = sum + water[day][time];

    }while((time >= 0) && (time < 24) && (day >= 0) && (day < 7));
```

Two-Dimensional Arrays

- **data_type** array_name [number_of_rows][number_of_columns];

int a[3][4];



	Column 0	Column 1	Column 2	Column 3
Row 0	a[0] [0]	a[0] [1]	a[0] [2]	a[0] [3]
Row 1	a[1] [0]	a[1] [1]	a[1] [2]	a[1] [3]
Row 2	a[2] [0]	a[2] [1]	a[2] [2]	a[2] [3]

position = (i × COLS)+ j+1
= (2 × 4) + 1 + 1 = 10.

- The elements are stored in row order with the elements of row 0 first, followed by the elements of row 1, and so on.

2D Array Initialisation

- int arr[3][3] = {{10, 20, 30},{40, 50, 60},{70, 80, 90}};
- int arr[3][3] = {10, 20, 30, 40, 50, 60, 70, 80, 90};
- int arr[3][3] = {{10, 20},{40, 50},{70}};

Remaining elements are set to zero.

- int arr[][3] = {10, 20, 30, 40, 50, 60};

Same as arr[2][3];

Overview

- One dimensional array
- Two dimensional array
- **String or char array**

Array: Char to String

A string such as "hello" is really an array of individual characters in C.

For example,

```
char array1[] = "first";
```

initializes the elements of array array1 to the individual characters in the string literal "first".

The preceding definition is equivalent to

```
char array1[] = { 'f', 'i', 'r', 's', 't', '\0' };
```

String

ASCII code for '\0' is zero
ASCII code for 0 is 48!!

- A series of characters that end with a special character, the null character, '\0'
- e.g. "message" requires 8 bytes (7 character + null character)
- char str[8];
- char str[8] = "message";
- char str[] = "message";
- char str[] = {'m', 'e', 's', 's', 'a', 'g', 'e', '\0'};

Could get unpredicted results if no space for '\0'

Writing Strings: examples

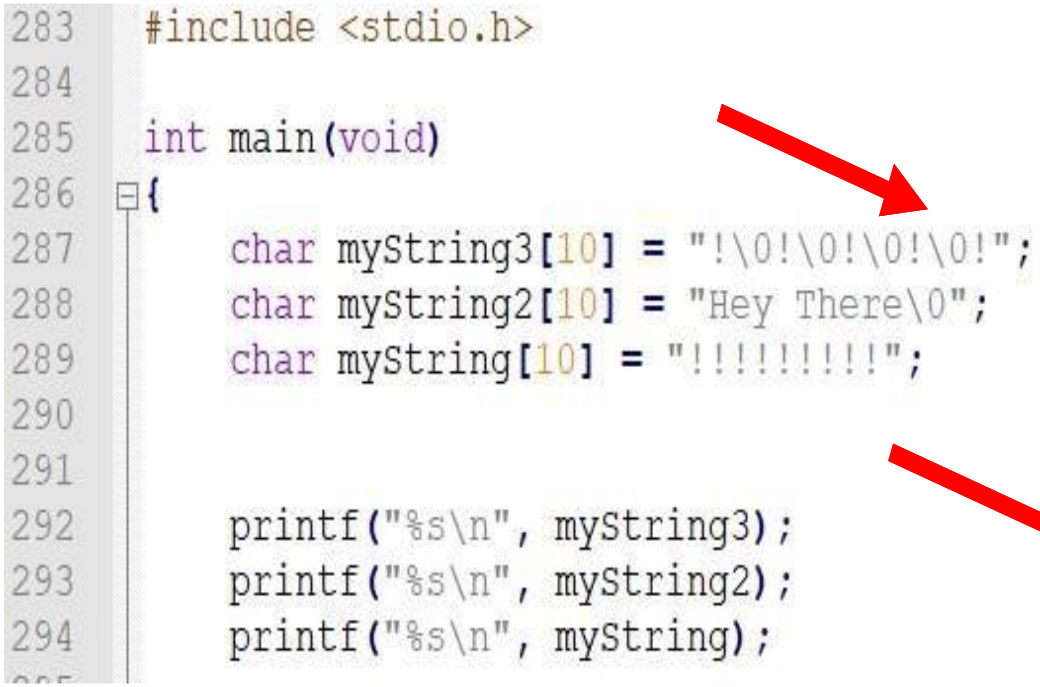
```
char str[10];
str[0] = ‘a’;
printf(“%s\n”, str);
```

```
char str[10] = {0};
str[0] = ‘a’;
printf(“%s\n”, str);
```

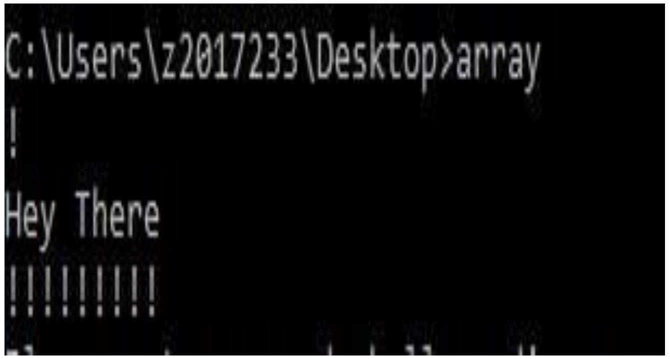
```
char str[10];
str[0] = ‘a’;
str[1] = ‘\0’;
printf(“%s\n”, str);
```

printf and '\0'

- printf prints until null character.



```
#include <stdio.h>

int main(void)
{
    char myString3[10] = "!\0!\0!\0!\0!";
    char myString2[10] = "Hey There\0";
    char myString[10] = "!!!!!!!!!";


    printf("%s\n", myString3);
    printf("%s\n", myString2);
    printf("%s\n", myString);
```



```
C:\Users\z2017233\Desktop>array
!
Hey There
!!!!!!!!!
```

Read Strings

- scanf() reads characters until it encounters a space character i.e. space, tab or new line character
- Then appends a null character at the end of the string

Read Strings (2)

```
#include <stdio.h>
int main()
{
    char name[20];
    printf("Enter name: ");
    scanf("%s", name);
    printf("Your name is %s.", name);
    return 0;
}
```

Output:

```
Enter name: Dennis Ritchie
Your name is Dennis.
```

Read Strings(3)

- fgets() function reads a line of string.
  - use puts() to display the string.

```
#include <stdio.h>
int main()
{
    char name[30];
    printf("Enter name: ");
    fgets(name, sizeof(name), stdin);  // read string
    printf("Name: ");
    puts(name);    // display string
    return 0;
}
```

Output:

```
Enter name: Tom Hanks
Name: Tom Hanks
```

Read Strings(4)

```
#include <stdio.h>

int main () {
   char str[50];

   printf("Enter a string : ");
   gets(str);

   printf("You entered: %s", str);

   return(0);
}
```

gets() removed from C library as it allows you to input any length of characters.

Hence, there might be a buffer overflow.

Output:

```
Enter a string : good tutorial
You entered: good tutorial
```

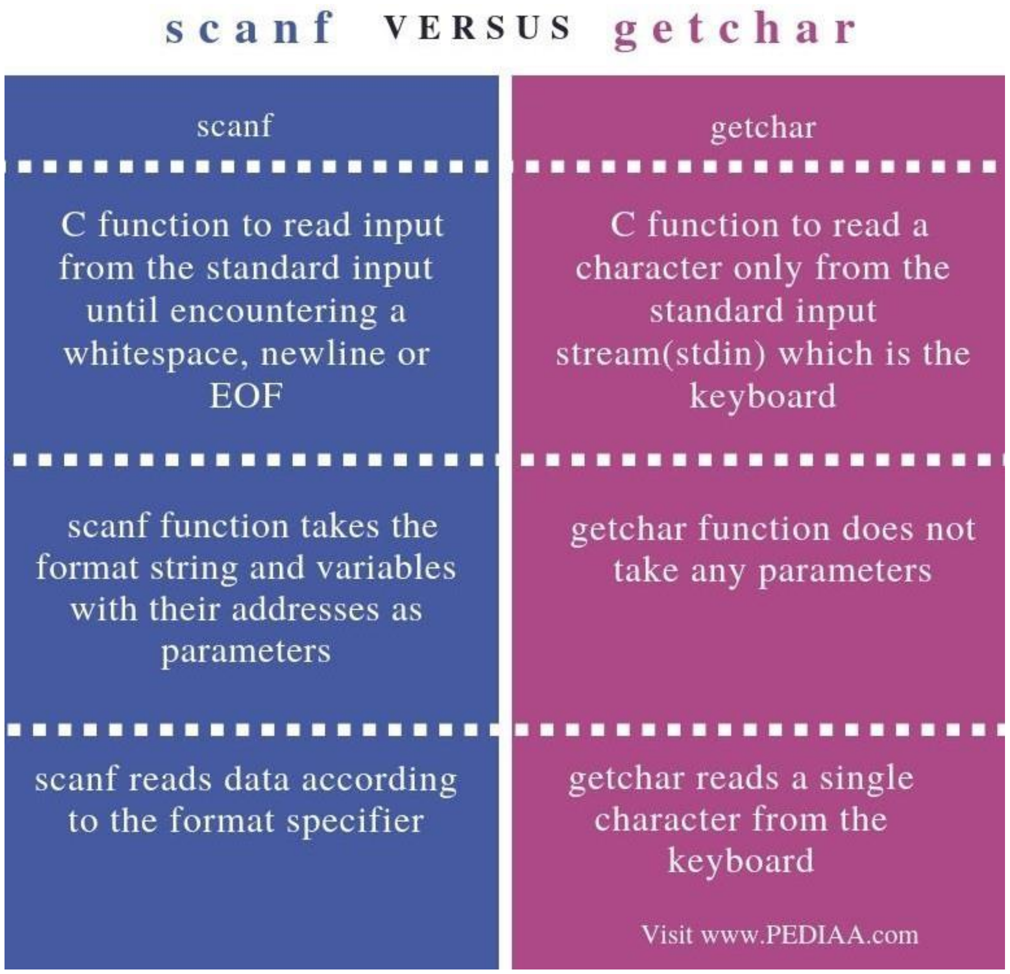
getchar() function

- … and we are back on input buffer again!!!

```
#include <stdio.h>

int main () {
   char c;

   printf("Enter character: ");
   c = getchar();

   printf("Character entered: ");
   putchar(c);

   return(0);
}
```

getchar vs. scanf

- scanf is a **formatted** of reading input from the keyboard.
- getchar reads a single character from the keyboard.



scanf VERSUS getchar

scanf	getchar
C function to read input from the standard input until encountering a whitespace, newline or EOF	C function to read a character only from the standard input stream(stdin) which is the keyboard
scanf function takes the format string and variables with their addresses as parameters	getchar function does not take any parameters
scanf reads data according to the format specifier	getchar reads a single character from the keyboard

Visit www.PEDIAA.com

Source: https://pediaa.com/what-is-the-difference-between-scanf-and-getchar/

Example: calculate average

```c
#include <stdio.h>
int main()
{
    int marks[10], i, n, sum = 0, average;

    printf("Enter number of elements: ");
    scanf("%d", &n);

    for(i=0; i<n; ++i)
    {
        printf("Enter number%d: ",i+1);
        scanf("%d", &marks[i]);

        // adding integers entered by the user to the sum variable
        sum += marks[i];
    }

    average = sum/n;
    printf("Average = %d", average);

    return 0;
}
```

Output:

```
Enter n: 5
Enter number1: 45
Enter number2: 35
Enter number3: 38
Enter number4: 31
Enter number5: 49
Average = 39
```

Summary

- One dimensional array
- Two dimensional array
- String or char array