INFORMATIKA
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NUSANTARA

IF232

ALGORITHMS & DATA STRUCTURES

01
ARRAYS & POINTERS

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OUTLINE

Arrays

Pointers

Strings

ARRAYS

- Array: a group of memory locations → **same name & same type**
- To refer to a particular location or element in the array, we specify the **name** of the array and the **position number** of the particular element in the array
- The first element in every array is the **zeroth (0th) element**
- The position number contained within square brackets is more formally called a **subscript** or **index** → must be an integer or integer expression

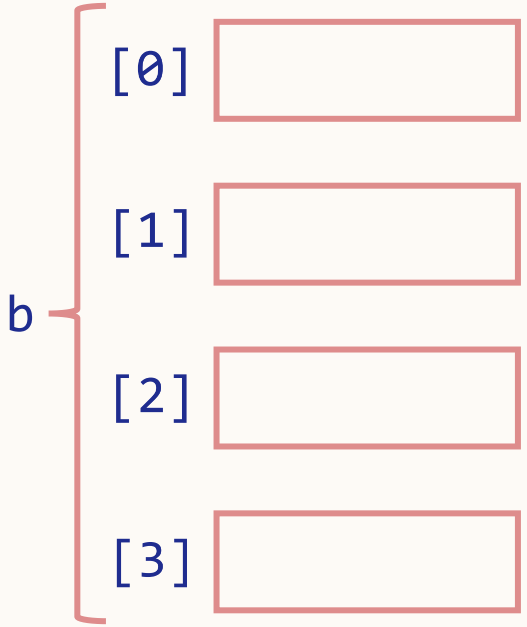
ARRAY DECLARATION

- Syntax

```
element_data_type array_name[size];
```

- Example

```
int a[100];
int b[4];
```



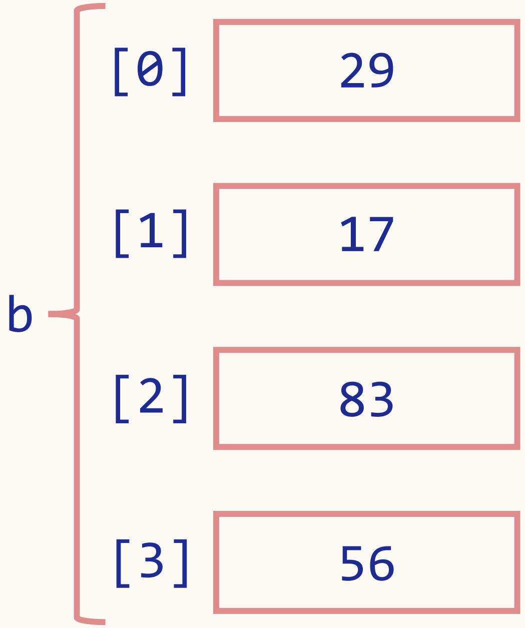
ARRAY INITIALIZATION

- Initialization using for statements

```
int a[100], i;

for(i = 0;i < 100;i++)
{
    a[i] = 0;
}
```

- Initialization using an initializer list

```
int b[4] = {29,17,83,56};
```



ARRAY INITIALIZATION

- If there are fewer initializers than elements in the array, the remaining elements are initialized to zero

```
int a[100] = {0};
```

  - This explicitly initializes the first element to zero and initializes the remaining 99 elements to zero

- If the array size is omitted from a definition with an initializer list, the number of elements in the array will be the number of elements in the initializer list

```
int b[] = {29,17,83,56};
```

  - This would create a four-element array

ARRAY ACCESS

- Syntax

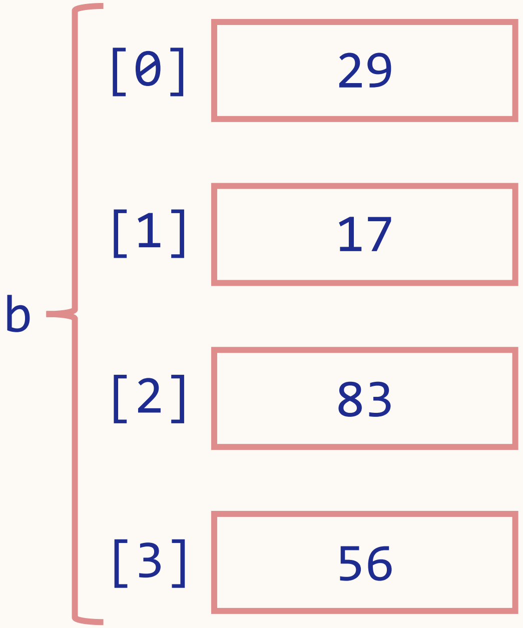
```
array_name[index]
```

- Example
  - How to print 83 ?

```
printf(“%d”,b[2]);
```

  - How to print 29 ?

```
printf(“%d”,b[0]);
```



b

[0] 29

[1] 17

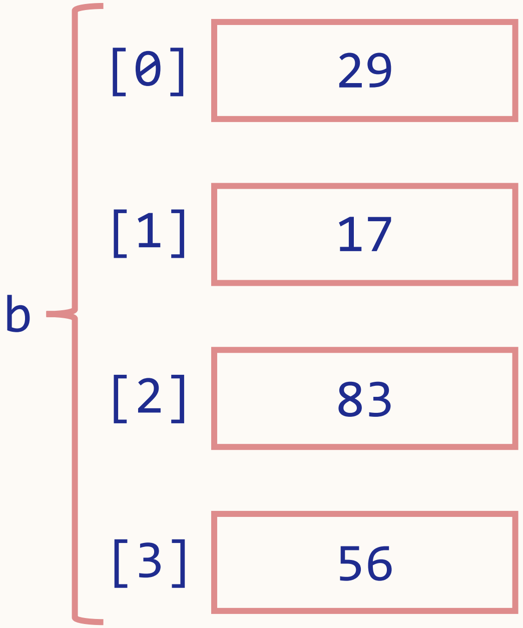
[2] 83

[3] 56

ARRAY ACCESS

- Using for loops for sequential access

```
int i;

for(i = 0;i < 4;i++)
{
   printf("%d\n",b[i]);
}
```



b

[0] 29

[1] 17

[2] 83

[3] 56

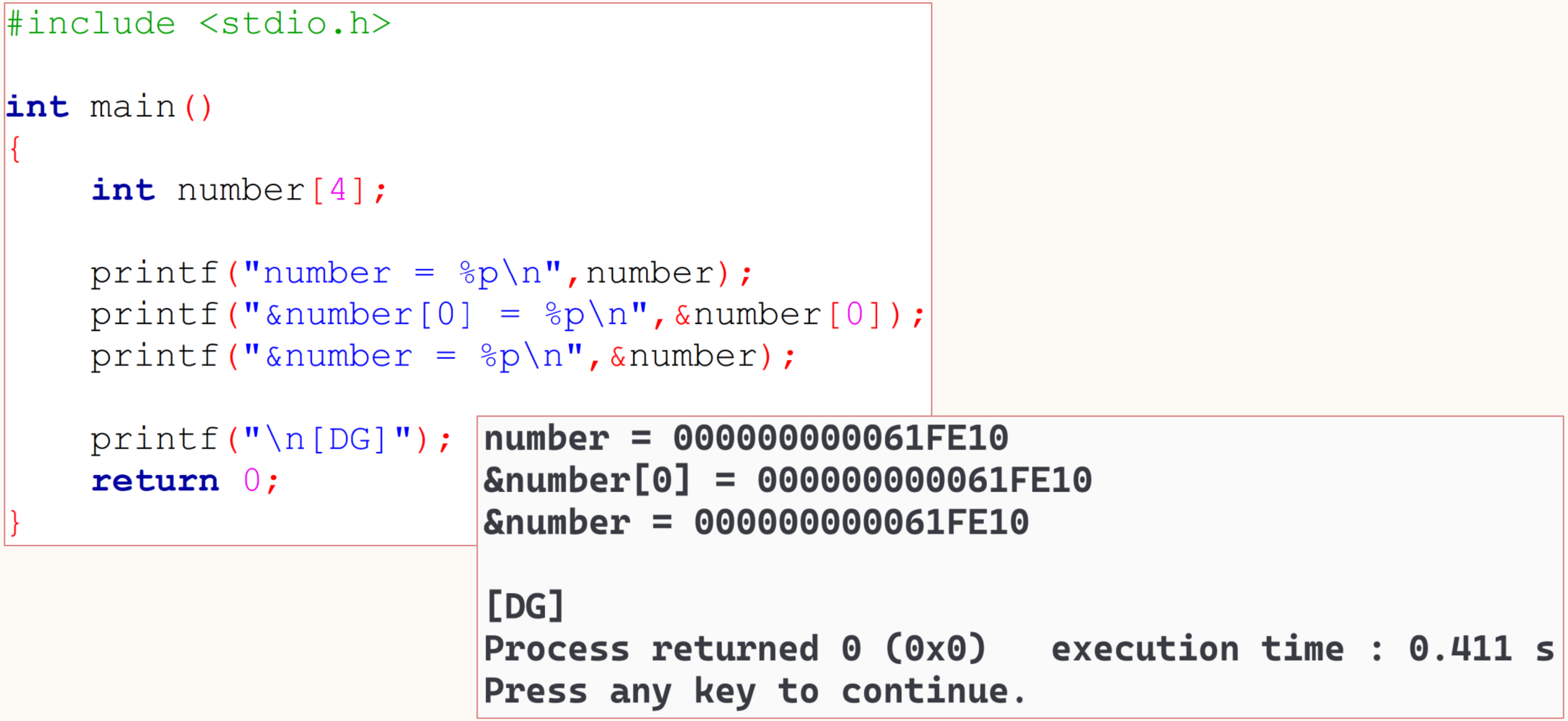
PASSING ARRAYS TO FUNCTIONS

- C automatically passes arrays to functions by reference
  - The called functions can modify the element values in the callers' original arrays

- The name of the array evaluates to the address of the first element of the array
  - **Array name is the same as the address of the array's first element**

```
array_name = &array_name[0]
```

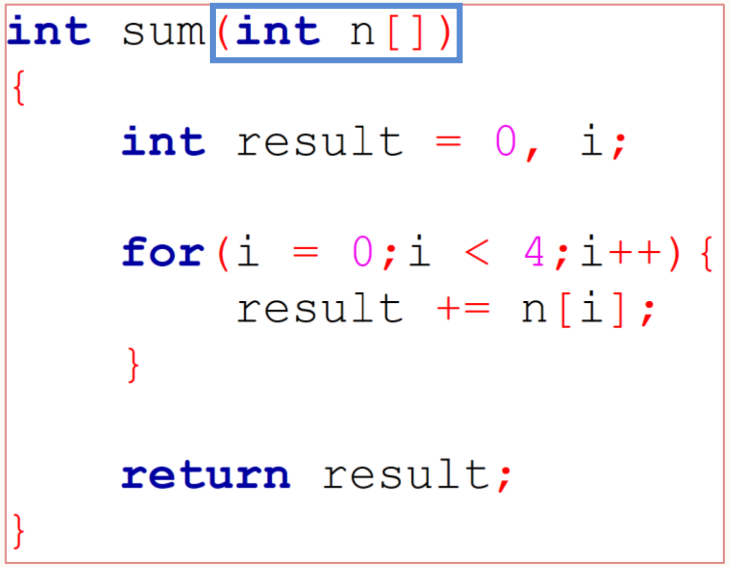
PASSING ARRAYS TO FUNCTIONS



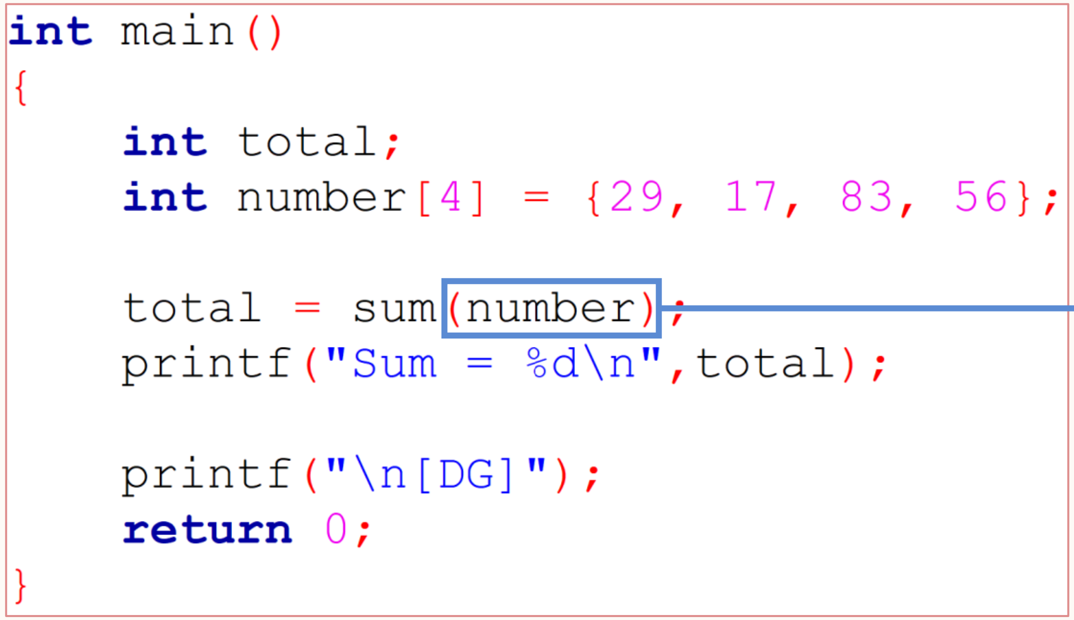
```c
#include <stdio.h>

int main()
{
    int number[4];

    printf("number = %p\n",number);
    printf("&number[0] = %p\n",&number[0]);
    printf("&number = %p\n",&number);

    printf("\n[DG]");
    return 0;
}
```

```
number = 000000000061FE10
&number[0] = 000000000061FE10
&number = 000000000061FE10

[DG]
Process returned 0 (0x0)   execution time : 0.411 s
Press any key to continue.
```

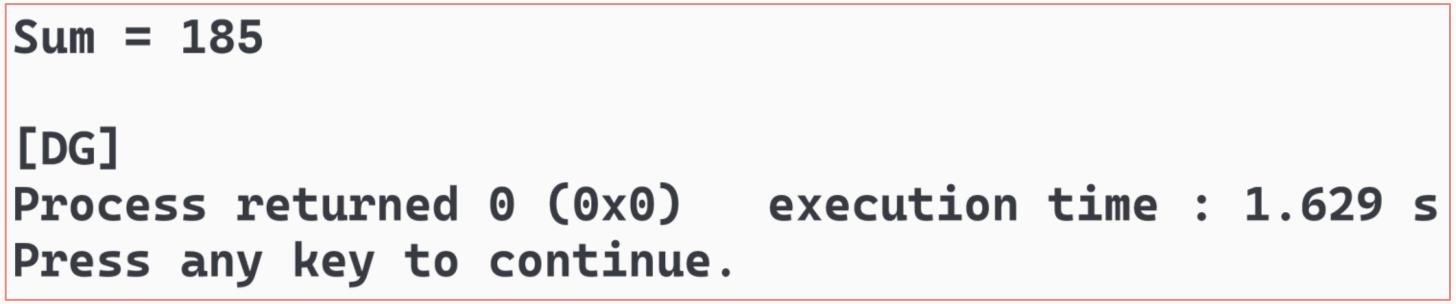
PASSING ARRAYS TO FUNCTIONS



```
int sum(int n[])
{
    int result = 0, i;

    for(i = 0;i < 4;i++){
        result += n[i];
    }

    return result;
}
```



```
int main()
{
    int total;
    int number[4] = {29, 17, 83, 56};

    total = sum(number);
    printf("Sum = %d\n",total);

    printf("\n[DG]");
    return 0;
}
```



```
Sum = 185

[DG]
Process returned 0 (0x0)   execution time : 1.629 s
Press any key to continue.
```

?

```
total = sum(&number[0]);
```

TWO-DIMENSIONAL ARRAYS

- Two-dimensional array is used to represent tables of data (tables of values consisting of information arranged in rows and columns), matrices, and other two-dimensional objects

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

MULTIDIMENSIONAL ARRAYS

- Declaration

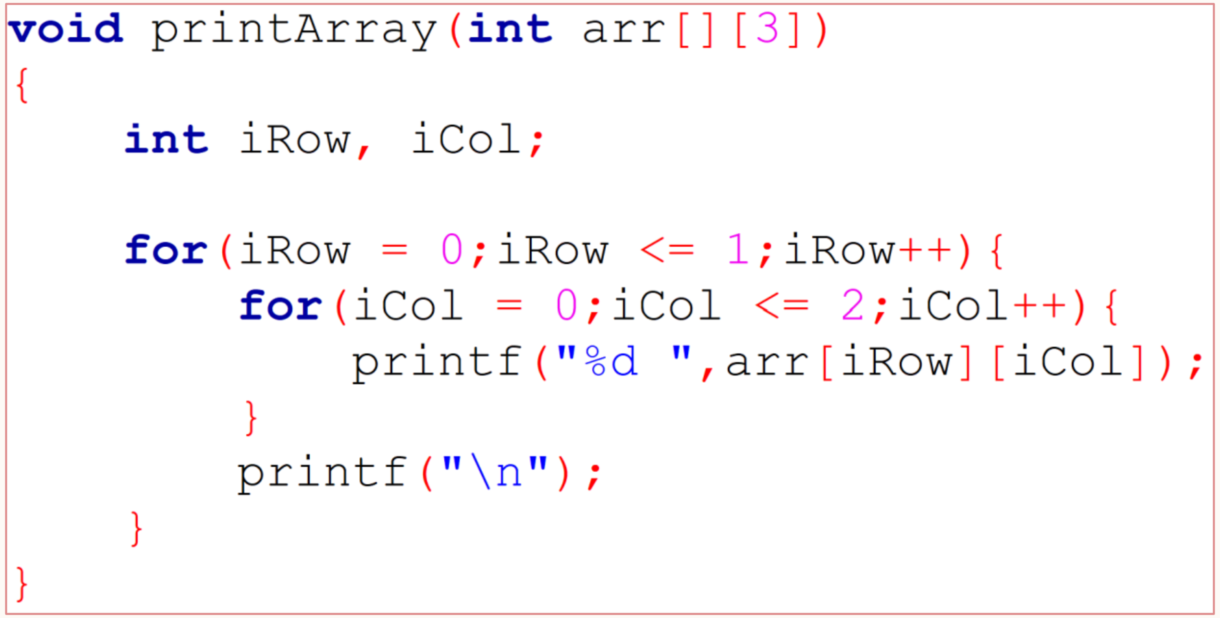
element_data_type array_name[size_1][size_2]...[size_n];

- As a function parameter

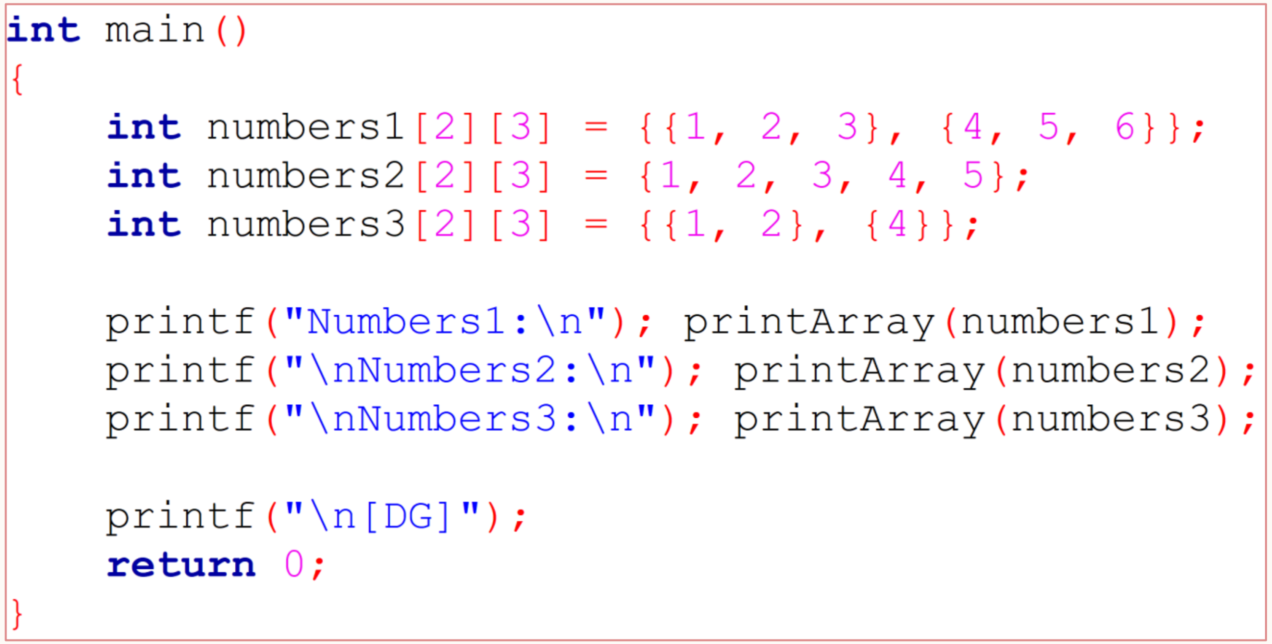
element_data_type array_name[size_1][size_2]...[size_n];

element_data_type array_name[][size_2]...[size_n];

MULTIDIMENSIONAL ARRAYS

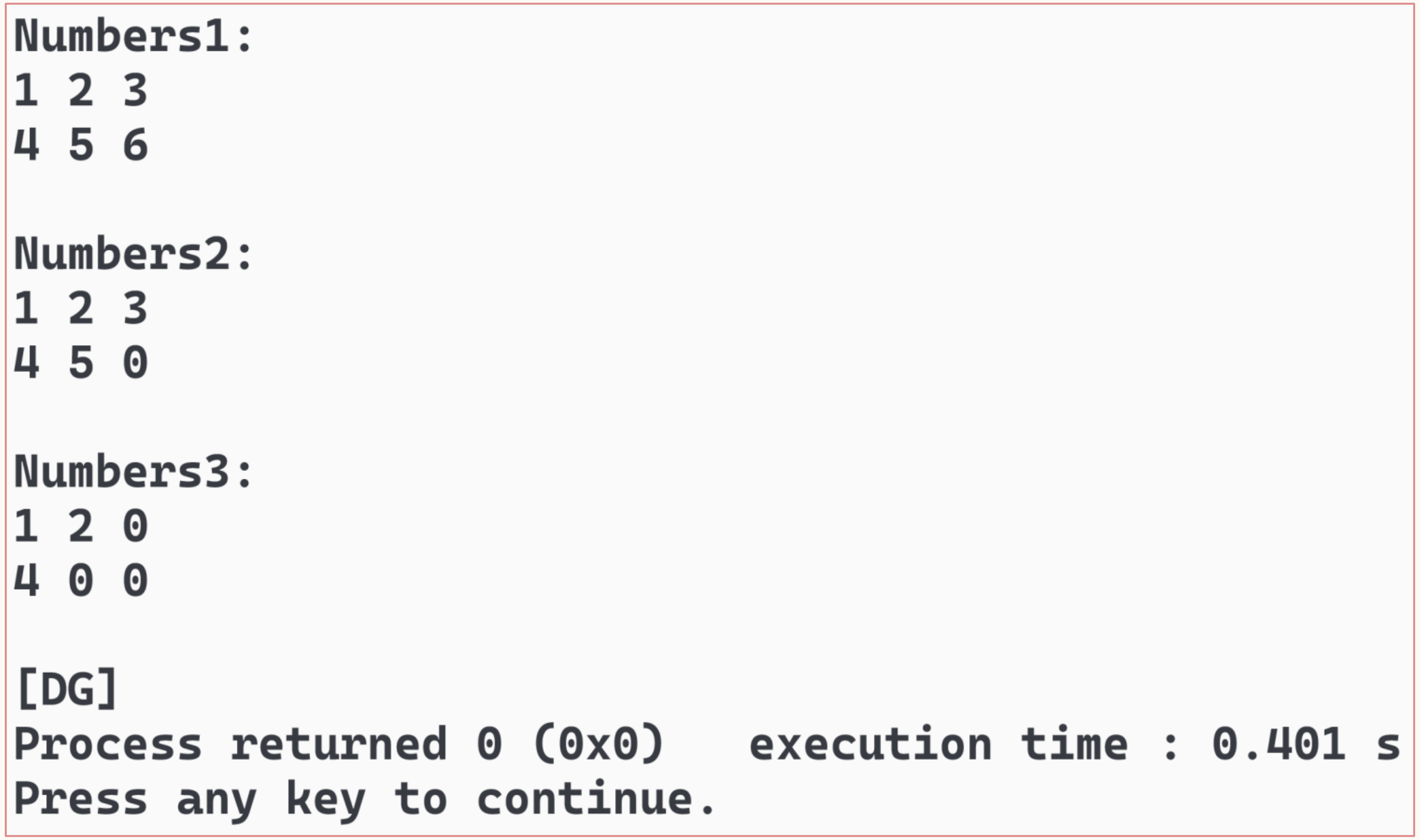


```c
void printArray(int arr[][3])
{
    int iRow, iCol;

    for(iRow = 0;iRow <= 1;iRow++){
        for(iCol = 0;iCol <= 2;iCol++){
            printf("%d ",arr[iRow][iCol]);
        }
        printf("\n");
    }
}
```



```c
int main()
{
    int numbers1[2][3] = {{1, 2, 3}, {4, 5, 6}};
    int numbers2[2][3] = {1, 2, 3, 4, 5};
    int numbers3[2][3] = {{1, 2}, {4}};

    printf("Numbers1:\n"); printArray(numbers1);
    printf("\nNumbers2:\n"); printArray(numbers2);
    printf("\nNumbers3:\n"); printArray(numbers3);

    printf("\n[DG]");
    return 0;
}
```

MULTIDIMENSIONAL ARRAYS



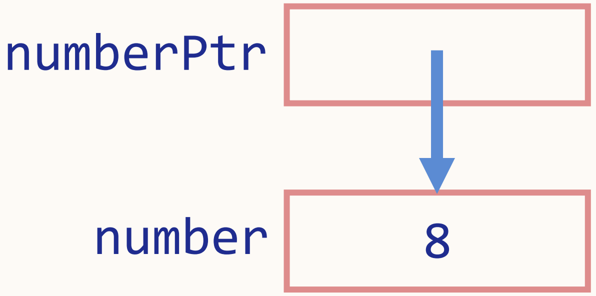
```
Numbers1:
1 2 3
4 5 6

Numbers2:
1 2 3
4 5 0

Numbers3:
1 2 0
4 0 0

[DG]
Process returned 0 (0x0)   execution time : 0.401 s
Press any key to continue.
```

POINTER VARIABLE DEFINITIONS & INITIALIZATION

- Pointers are variables whose values are memory addresses
- A pointer contains an address of a variable that contains a specific value
- A variable name directly references a value, but a pointer indirectly references a value

Pointer **numberPtr** indirectly references the value 8

Variable **number** directly contains the value 8



POINTER VARIABLE DEFINITIONS & INITIALIZATION

- Pointers must be defined before they can be used

```
data_type *pointer_name;
```

- Example

```
int *iPtr;
```

  - What is the data type of iPtr ?

```
int *iPtr;
```

  - What is the data type of *iPtr ?

```
int *iPtr;
```

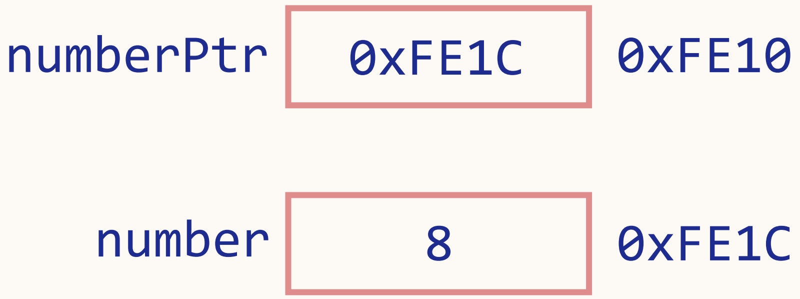
POINTER VARIABLE DEFINITIONS & INITIALIZATION

- Pointers should be initialized either when they are defined or in an assignment statement
- A pointer may be initialized to NULL or an address
- A pointer with the value NULL points to nothing

POINTER OPERATORS

- The address operator (&) returns the address of its operand (variable)
- The indirection operator / dereferencing operator (*) returns the value of the object to which its operand (pointer) points

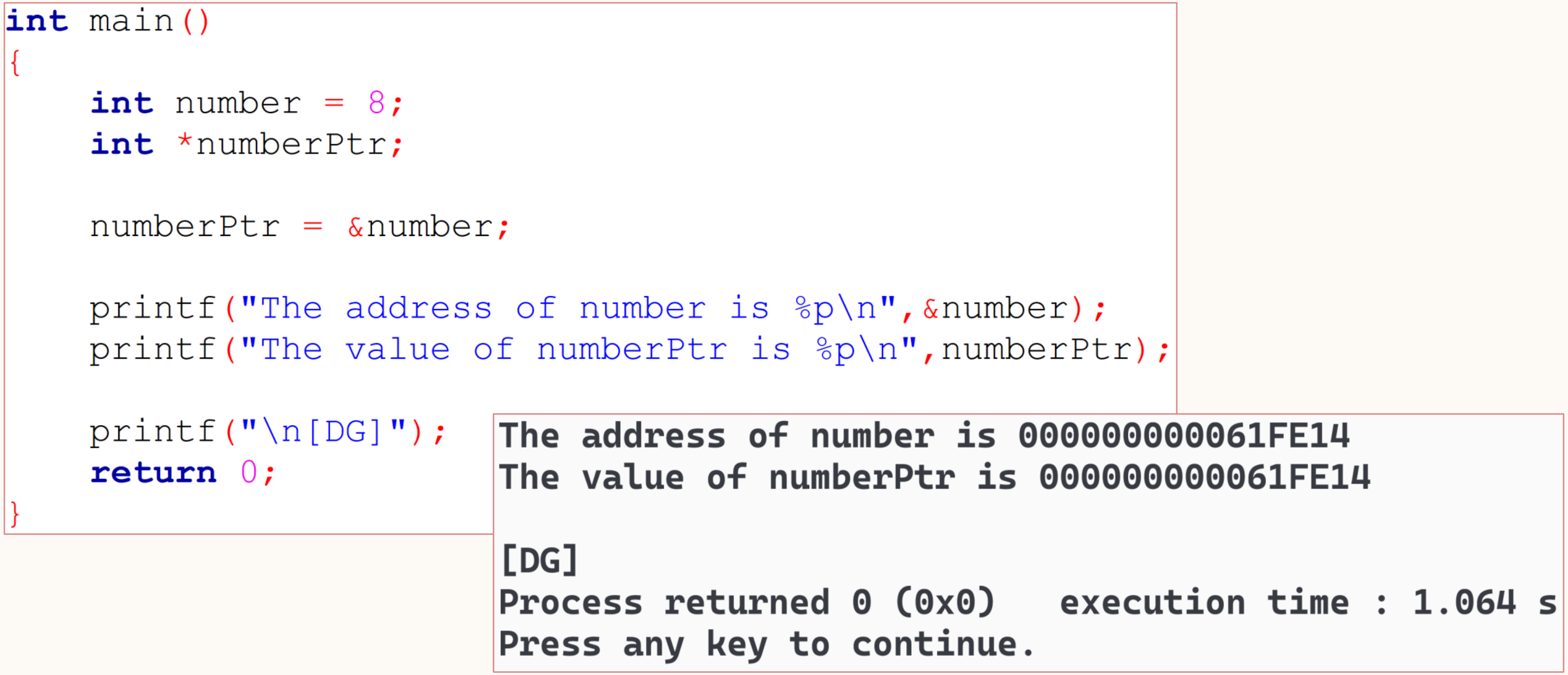
```
int number = 8;
int *numberPtr;

numberPtr = &number;

printf(“%d”,*numberPtr);
```



numberPtr 0xFE1C 0xFE10

number 8 0xFE1C

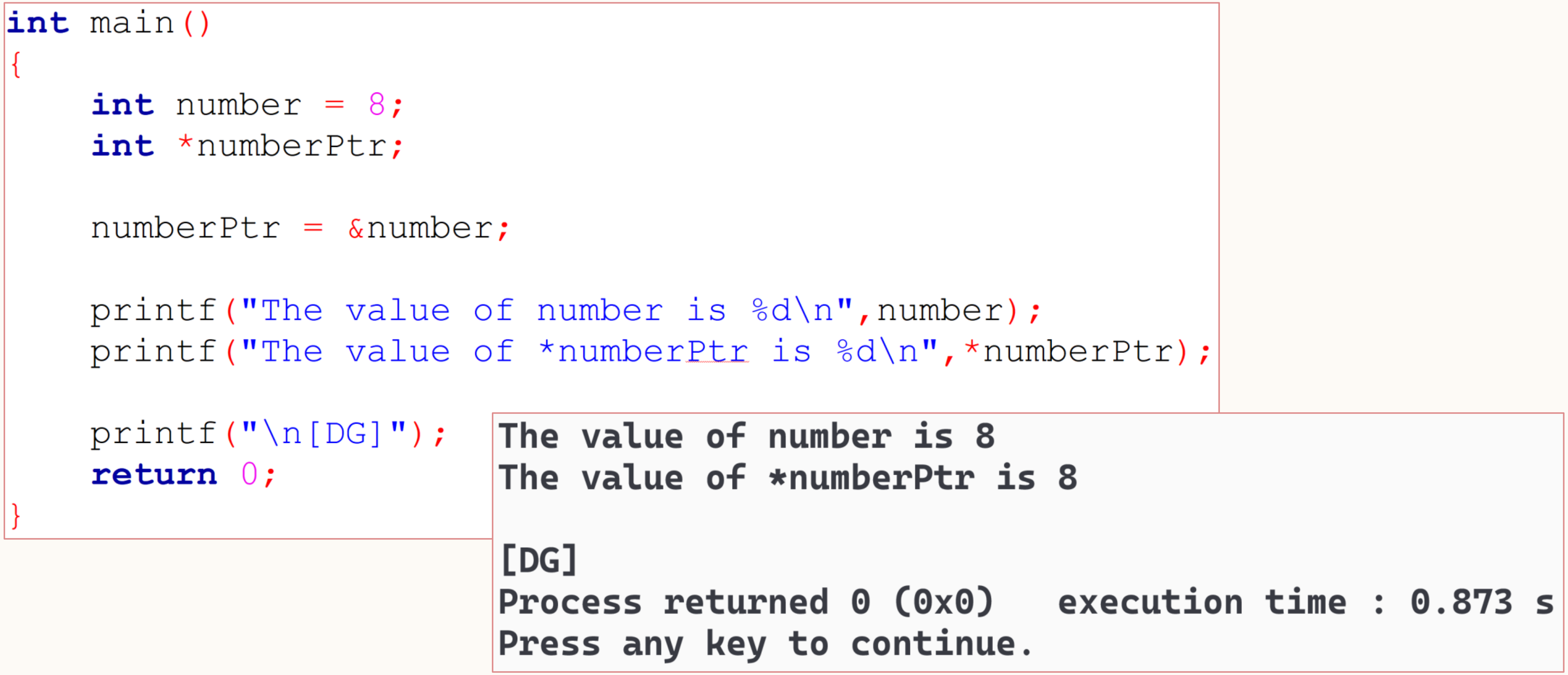
POINTER OPERATORS



```c
int main()
{
    int number = 8;
    int *numberPtr;

    numberPtr = &number;

    printf("The address of number is %p\n",&number);
    printf("The value of numberPtr is %p\n",numberPtr);

    printf("\n[DG]");
    return 0;
}
```

```
The address of number is 000000000061FE14
The value of numberPtr is 000000000061FE14

[DG]
Process returned 0 (0x0)   execution time : 1.064 s
Press any key to continue.
```

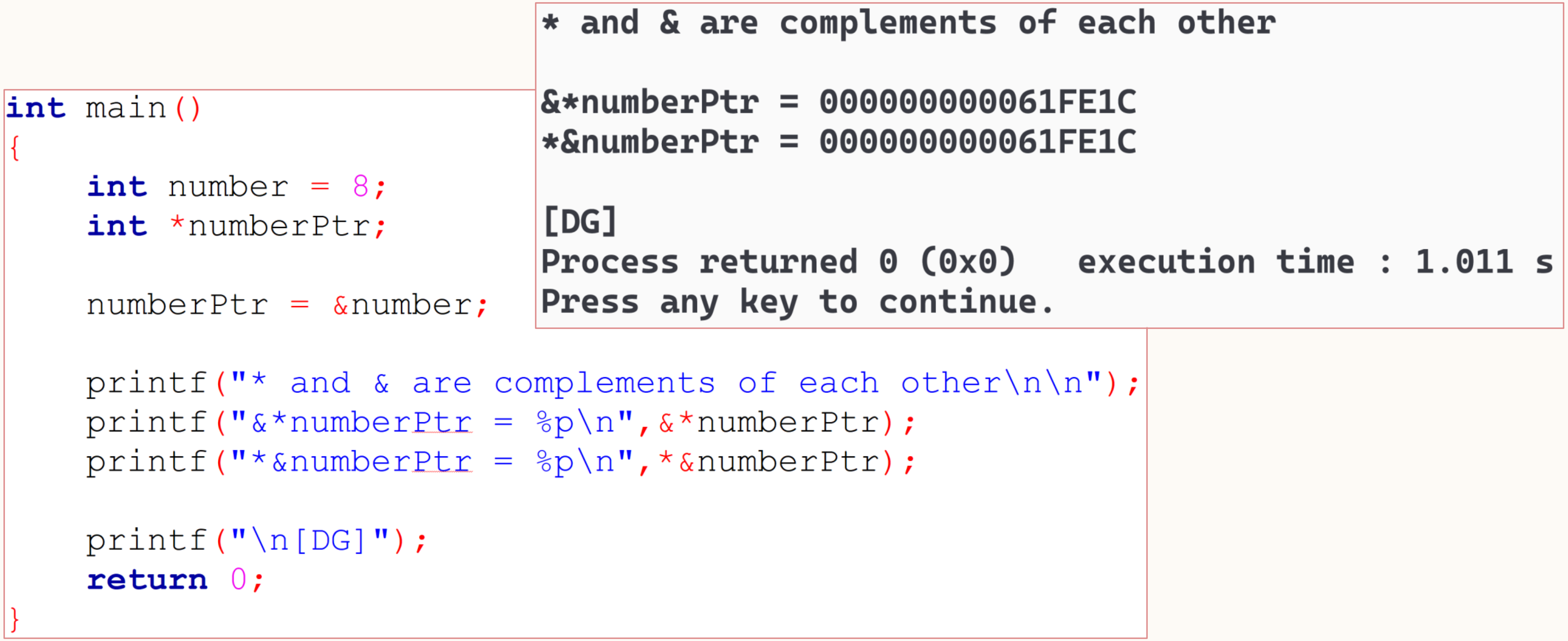
POINTER OPERATORS



```
int main()
{
    int number = 8;
    int *numberPtr;

    numberPtr = &number;

    printf("The value of number is %d\n",number);
    printf("The value of *numberPtr is %d\n",*numberPtr);

    printf("\n[DG]");
    return 0;
}
```

```
The value of number is 8
The value of *numberPtr is 8

[DG]
Process returned 0 (0x0)   execution time : 0.873 s
Press any key to continue.
```

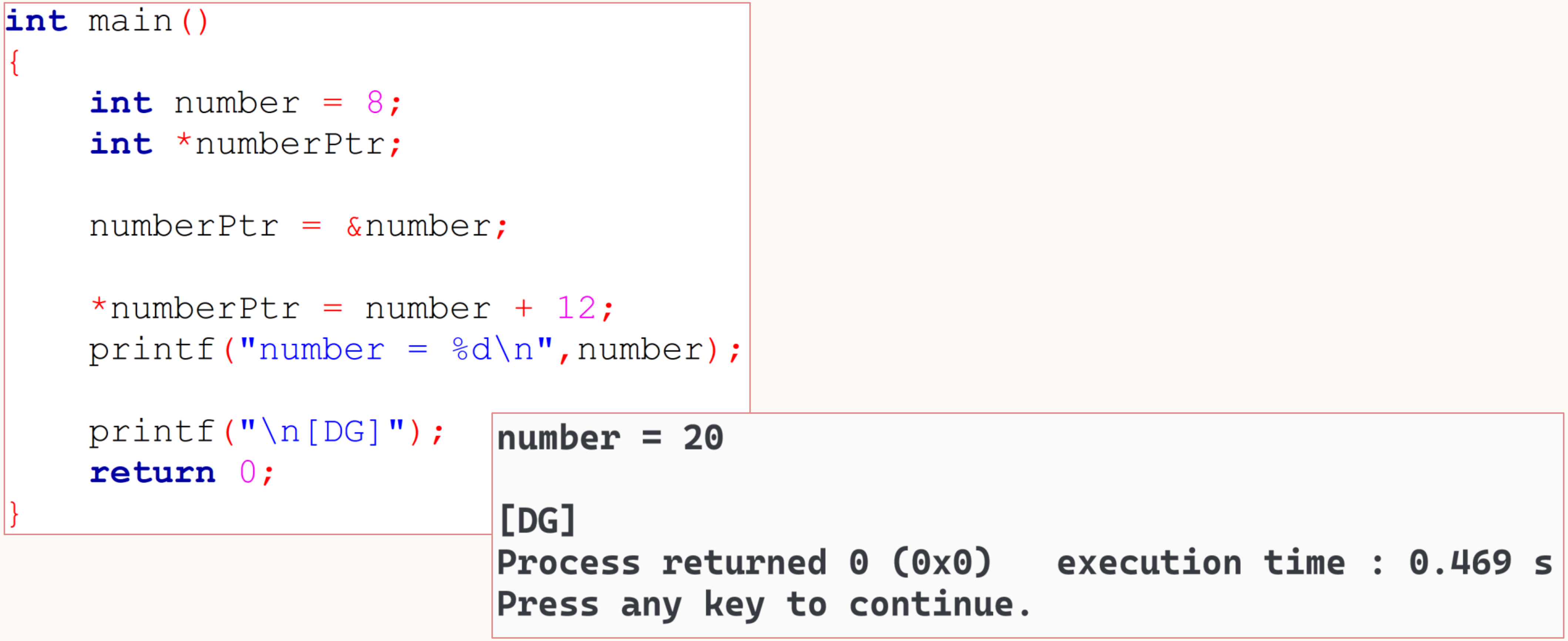
POINTER OPERATORS



```
int main()
{
    int number = 8;
    int *numberPtr;

    numberPtr = &number;

    printf("* and & are complements of each other\n\n");
    printf("&*numberPtr = %p\n",&*numberPtr);
    printf("*&numberPtr = %p\n",*&numberPtr);

    printf("\n[DG]");
    return 0;
}
```

```
* and & are complements of each other

&*numberPtr = 000000000061FE1C
*&numberPtr = 000000000061FE1C

[DG]
Process returned 0 (0x0)   execution time : 1.011 s
Press any key to continue.
```

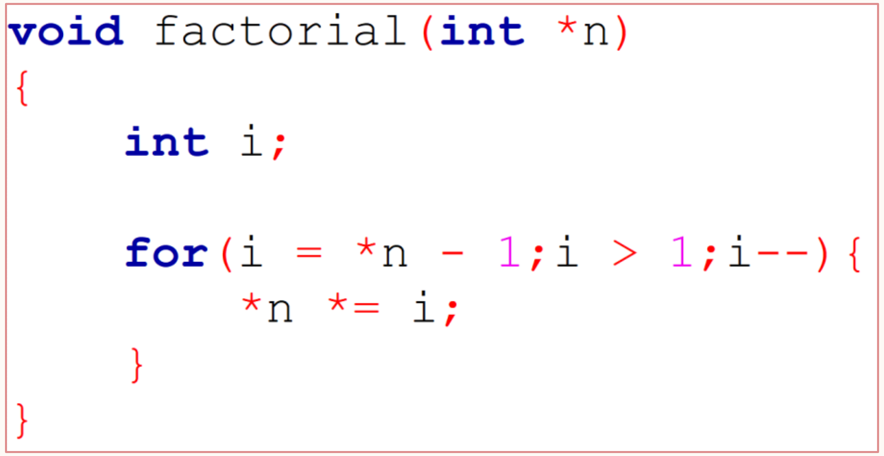
POINTER OPERATORS



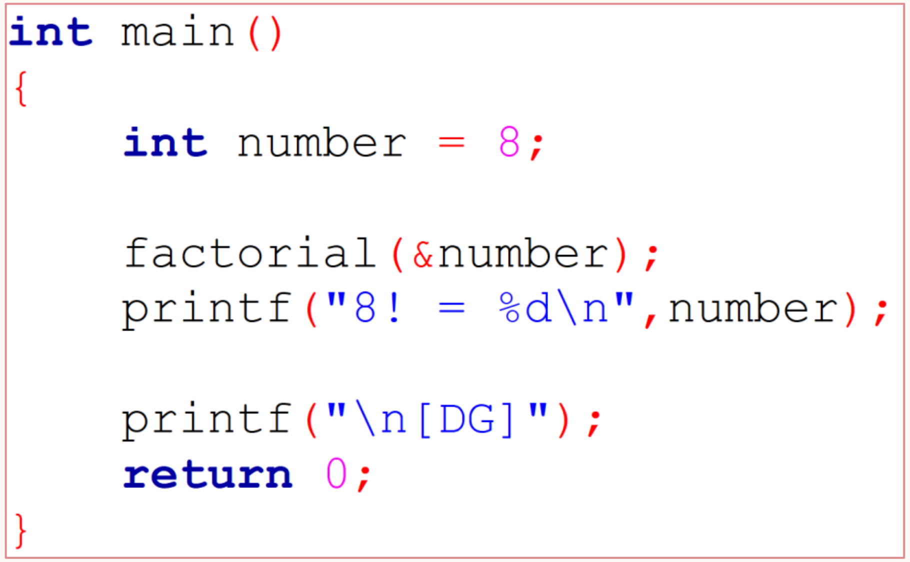
```
int main()
{
    int number = 8;
    int *numberPtr;

    numberPtr = &number;

    *numberPtr = number + 12;
    printf("number = %d\n",number);

    printf("\n[DG]");
    return 0;
}
```

```
number = 20

[DG]
Process returned 0 (0x0)   execution time : 0.469 s
Press any key to continue.
```

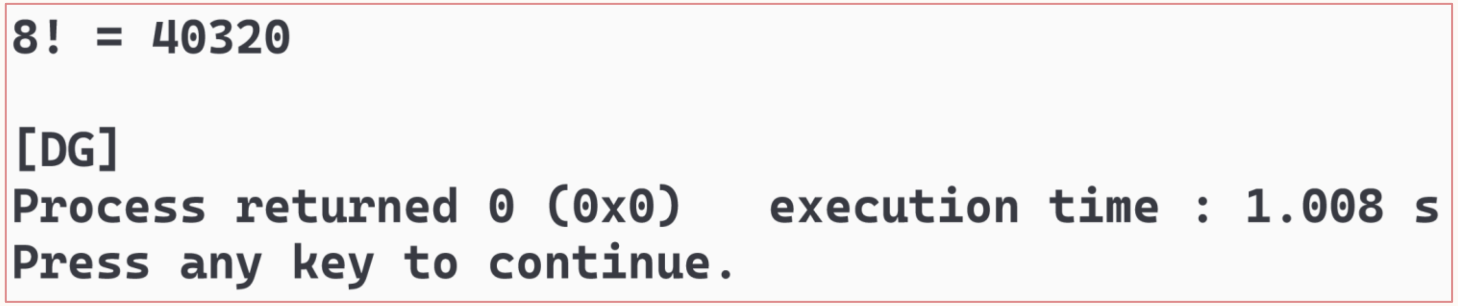
CALL BY POINTER



```c
void factorial(int *n)
{
    int i;

    for(i = *n - 1;i > 1;i--){
        *n *= i;
    }
}
```



```c
int main()
{
    int number = 8;

    factorial(&number);
    printf("8! = %d\n",number);

    printf("\n[DG]");
    return 0;
}
```



```
8! = 40320

[DG]
Process returned 0 (0x0)   execution time : 1.008 s
Press any key to continue.
```

POINTERS & ARRAYS

```
int arr[7];
int *arrPtr;
```

- Since the array name (without a subscript) is a pointer to the first element of the array, we can set **arrPtr** equal to the address of the first element in array **arr**

```
arrPtr = arr;
```

=

```
arrPtr = &arr[0];
```

POINTERS & ARRAYS

```
int arr[7];
int *arrPtr;
```

- The address **&arr[n]** can be written with the pointer expression

```
arrPtr + n
```

- Array element **arr[n]** can alternatively be referenced with the pointer expression

```
*(arrPtr + n)
```

POINTERS & ARRAYS

```
int arr[7];
int *arrPtr;
```

- The array itself can be treated as a pointer

```
*(arr + n)
```

- Pointers can be subscripted exactly as arrays can

```
arrPtr[n]
```

STRINGS

- A string is a series of characters treated as a single unit
- A string may include letters, digits, and various special characters
- String literals (string constants) in C are written in **double quotation marks**
- A string in C is an **array of characters ending in the null character (‘\0’)**
- A string is accessed via a pointer to the first character in the string
- The value of a string is the address of its first character

STRINGS

```
char color[] = “cyan”;
char color[] = {‘c’, ‘y’, ‘a’, ‘n’};
```

- Create a 5-element array color containing the characters ‘c’, ‘y’, ‘a’, ‘n’, and ‘\0’

color[0]	color[1]	color[2]	color[3]	color[4]
c	y	a	n	\0

```
char color[7] = “cyan”;
```

color[0]	color[1]	color[2]	color[3]	color[4]	color[5]	color[6]
c	y	a	n	\0		

STRINGS

```
char *color = “cyan”;
```

- Creates pointer variable color that points to the string “cyan” somewhere in memory

color[0]	color[1]	color[2]	color[3]	color[4]
c	y	a	n	\0

STRING LIBRARY FUNCTIONS

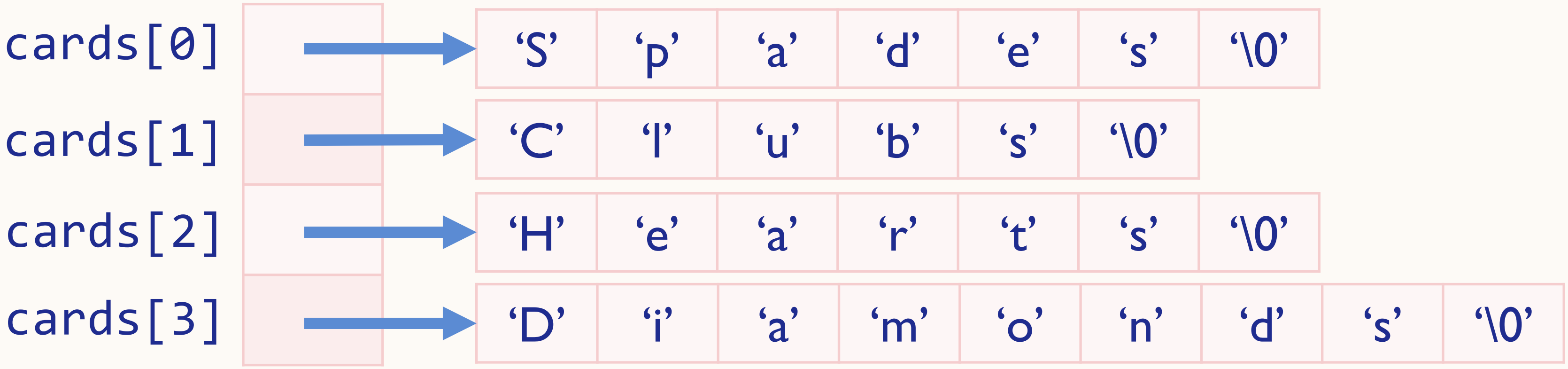
Function Prototype	Function Description
char *strcpy(char *s1, const char *s2);	**Copies string s2 into array s1** The value of s1 is returned
char *strncpy(char *s1, const char *s2, size_t n);	**Copies at most n characters of string s2 into array s1** The value of s1 is returned
char *strcat(char *s1, const char *s2);	**Appends string s2 to array s1** The first character of s2 overwrites the terminating null character of s1 The value of s1 is returned
size_t strlen(const char *s);	**Determines the length of string s** The number of characters preceding the terminating null character is returned

STRING LIBRARY FUNCTIONS

Function Prototype	Function Description
int strcmp(const char *s1, const char *s2);	**Compares the string s1 with the string s2** The function returns 0, less than 0, or greater than 0 if s1 is equal to, less than, or greater than s2, respectively
int strncmp(const char *s1, const char *s2, size_t n);	**Compares up to n characters of the string s1 with the string s2** The function returns 0, less than 0, or greater than 0 if s1 is equal to, less than, or greater than s2, respectively

ARRAYS OF STRINGS

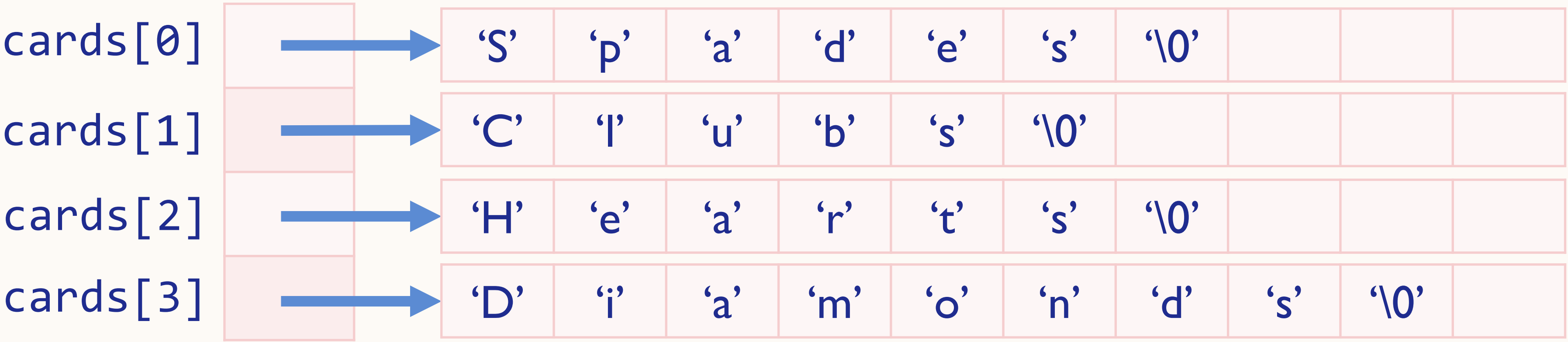
```
char *cards[4] = {“Spades”, “Clubs”, “Hearts”, “Diamonds”};
```



cards[0]	‘S’	‘p’	‘a’	‘d’	‘e’	‘s’	‘\0’		
cards[1]	‘C’	‘l’	‘u’	‘b’	‘s’	‘\0’			
cards[2]	‘H’	‘e’	‘a’	‘r’	‘t’	‘s’	‘\0’		
cards[3]	‘D’	‘i’	‘a’	‘m’	‘o’	‘n’	‘d’	‘s’	‘\0’

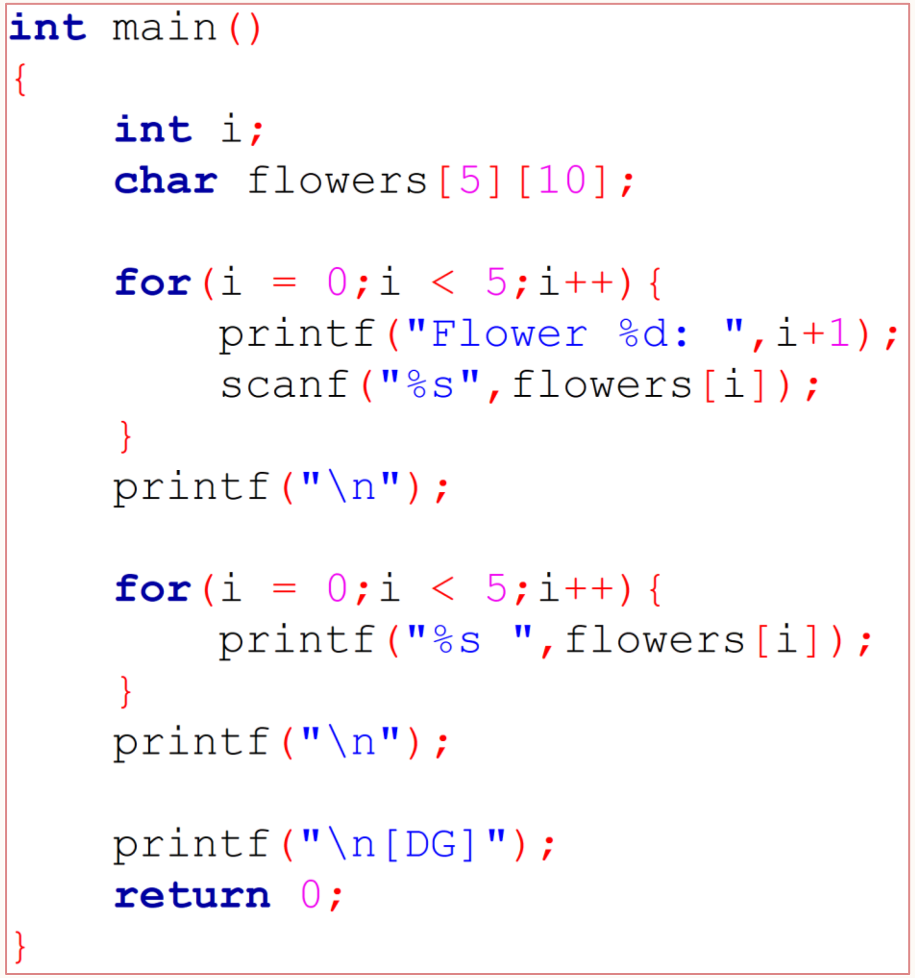
ARRAYS OF STRINGS

```
char cards[4][10] = {“Spades”, “Clubs”, “Hearts”, “Diamonds”};
```

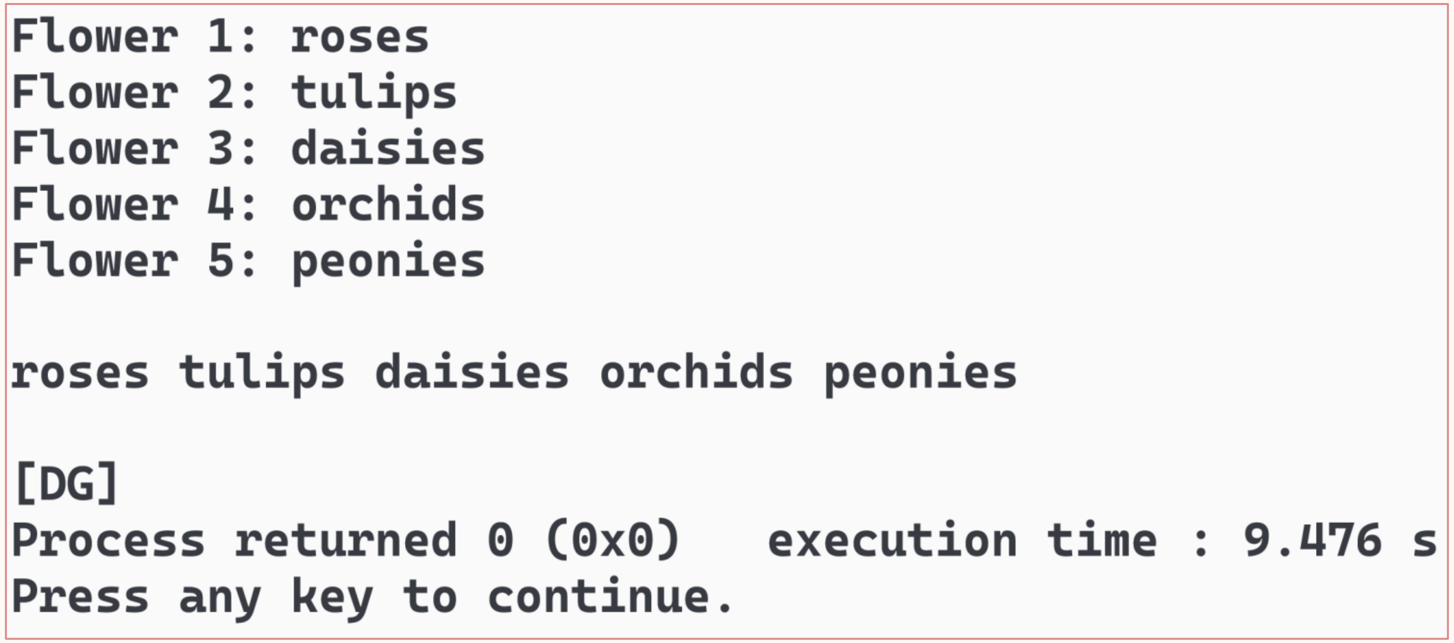


cards[0]	‘S’	‘p’	‘a’	‘d’	‘e’	‘s’	‘\0’			
cards[1]	‘C’	‘l’	‘u’	‘b’	‘s’	‘\0’				
cards[2]	‘H’	‘e’	‘a’	‘r’	‘t’	‘s’	‘\0’			
cards[3]	‘D’	‘i’	‘a’	‘m’	‘o’	‘n’	‘d’	‘s’	‘\0’	

ARRAYS OF STRINGS

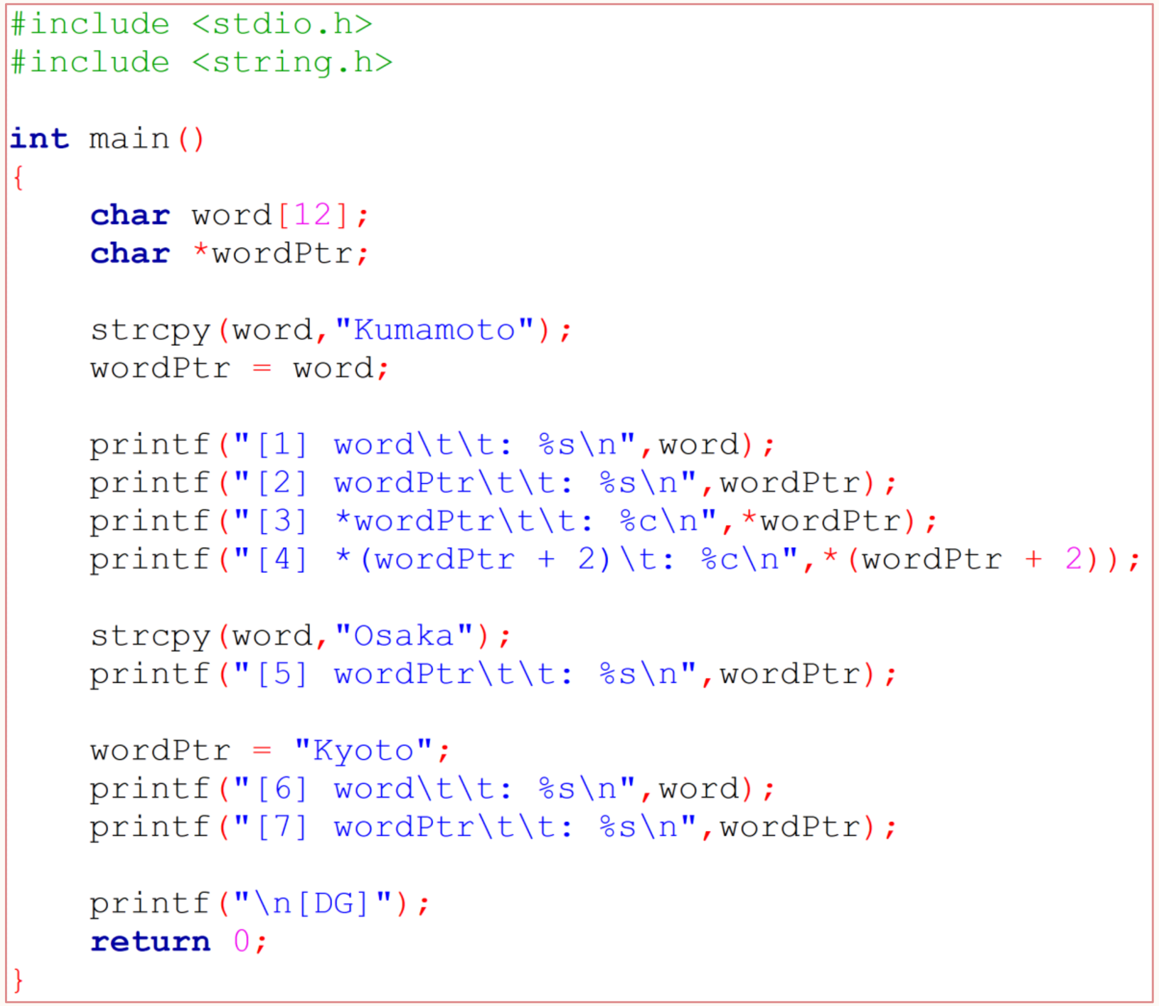


```
int main()
{
    int i;
    char flowers[5][10];

    for(i = 0;i < 5;i++){
        printf("Flower %d: ",i+1);
        scanf("%s",flowers[i]);
    }
    printf("\n");

    for(i = 0;i < 5;i++){
        printf("%s ",flowers[i]);
    }
    printf("\n");

    printf("\n[DG]");
    return 0;
}
```



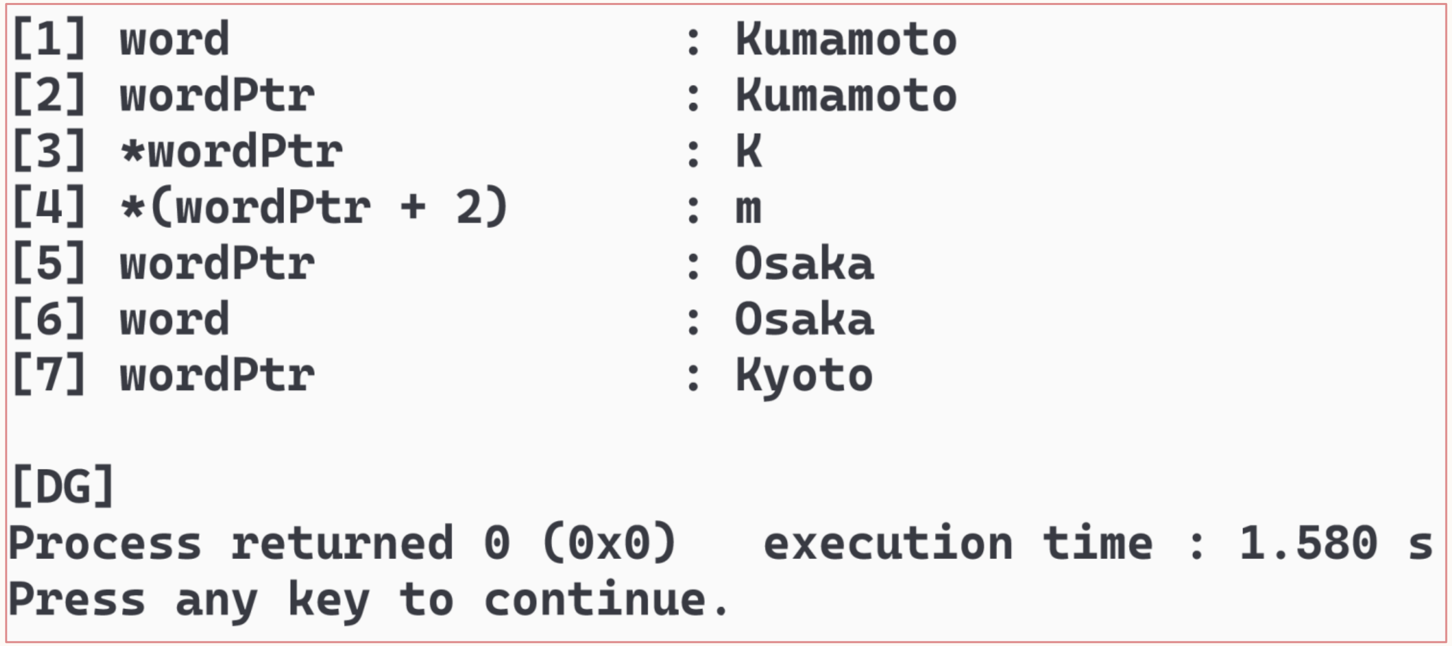
```
Flower 1: roses
Flower 2: tulips
Flower 3: daisies
Flower 4: orchids
Flower 5: peonies

roses tulips daisies orchids peonies

[DG]
Process returned 0 (0x0)   execution time : 9.476 s
Press any key to continue.
```

POINTER TO STRINGS



```c
#include <stdio.h>
#include <string.h>

int main()
{
    char word[12];
    char *wordPtr;

    strcpy(word,"Kumamoto");
    wordPtr = word;

    printf("[1] word\t\t: %s\n",word);
    printf("[2] wordPtr\t\t: %s\n",wordPtr);
    printf("[3] *wordPtr\t\t: %c\n",*wordPtr);
    printf("[4] *(wordPtr + 2)\t: %c\n",*(wordPtr + 2));

    strcpy(word,"Osaka");
    printf("[5] wordPtr\t\t: %s\n",wordPtr);

    wordPtr = "Kyoto";
    printf("[6] word\t\t: %s\n",word);
    printf("[7] wordPtr\t\t: %s\n",wordPtr);

    printf("\n[DG]");
    return 0;
}
```

POINTER TO STRINGS



```
[1] word                    : Kumamoto
[2] wordPtr                 : Kumamoto
[3] *wordPtr                : K
[4] *(wordPtr + 2)          : m
[5] wordPtr                 : Osaka
[6] word                    : Osaka
[7] wordPtr                 : Kyoto

[DG]
Process returned 0 (0x0)   execution time : 1.580 s
Press any key to continue.
```

PRACTICE

EXERCISES

1. Find the error in each of the following program segments and correct the error.

   a.

   ```
   int p[5] = {0};
   int i;

   for(i = 0;i <= 5;++i){
       p[i] = 1;
   }
   ```

   b.

   ```
   int n[2][2] = {{8, 7}, {6, 5}};
   n[1, 1] = 3;
   ```

EXERCISES

1. Find the error in each of the following program segments and correct the error.

c.

```
char w[5] = “”;
scanf(“%s”, w); // user types hello
```

d.

```
double d[3] = {1.1, 10.01, 100.001, 1000.0001};
```

e.

```
float f = 87.56;
float fPtr = &f;
printf(“%f\n”, fPtr);
```

EXERCISES

1. Find the error in each of the following program segments and correct the error.

f.

```
int *a, b;
a = b;
```

g.

```
int *iPtr, j;
int i[5] = {1, 2, 3, 4, 5};
iPtr = i;

printf(“%d\n”,iPtr);

for(j = 0;j <= 5;j++)
   printf(“%d\n”,*iPtr[j]);
```

EXERCISES

1. Find the error in each of the following program segments and correct the error.

h.

```
char str[10] = “”;
strncpy(str, “hello”, 5);
printf(“%s\n”, str);
```

i.

```
printf(“%s”, ‘a’);
```

j.

```
char str[12] = “”;
strcpy(str, “Welcome Home”);
```

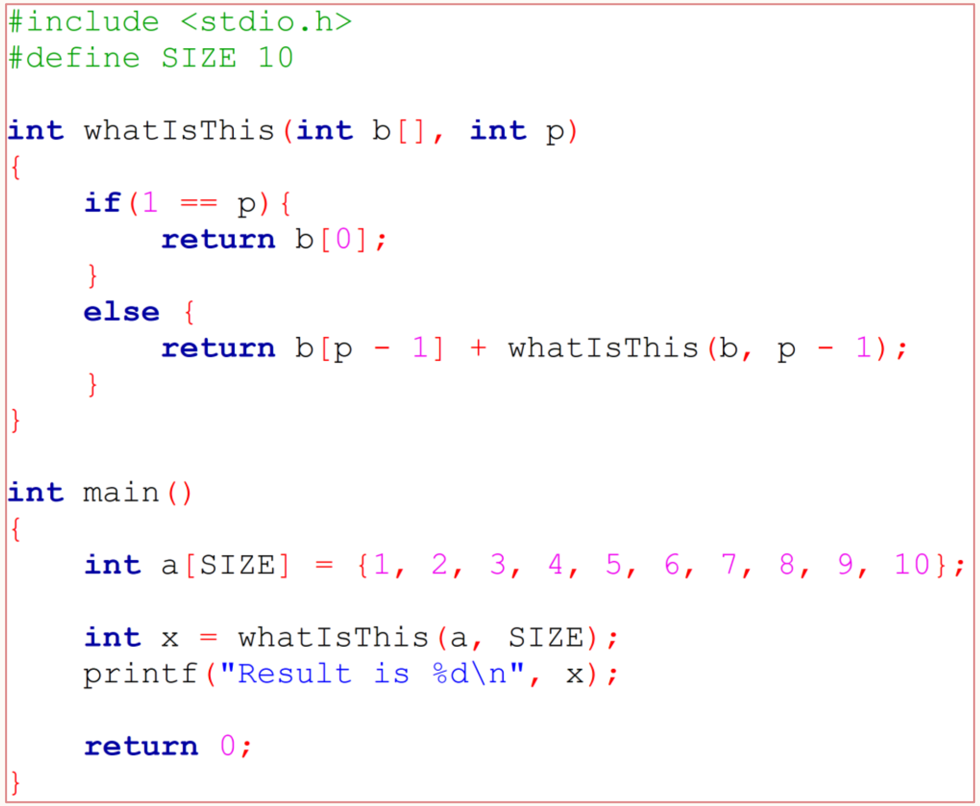
EXERCISES

1. Find the error in each of the following program segments and correct the error.
   k.

```
if(strcmp(string1, string2)){
    puts(“The strings are equal”);
}
```

EXERCISES

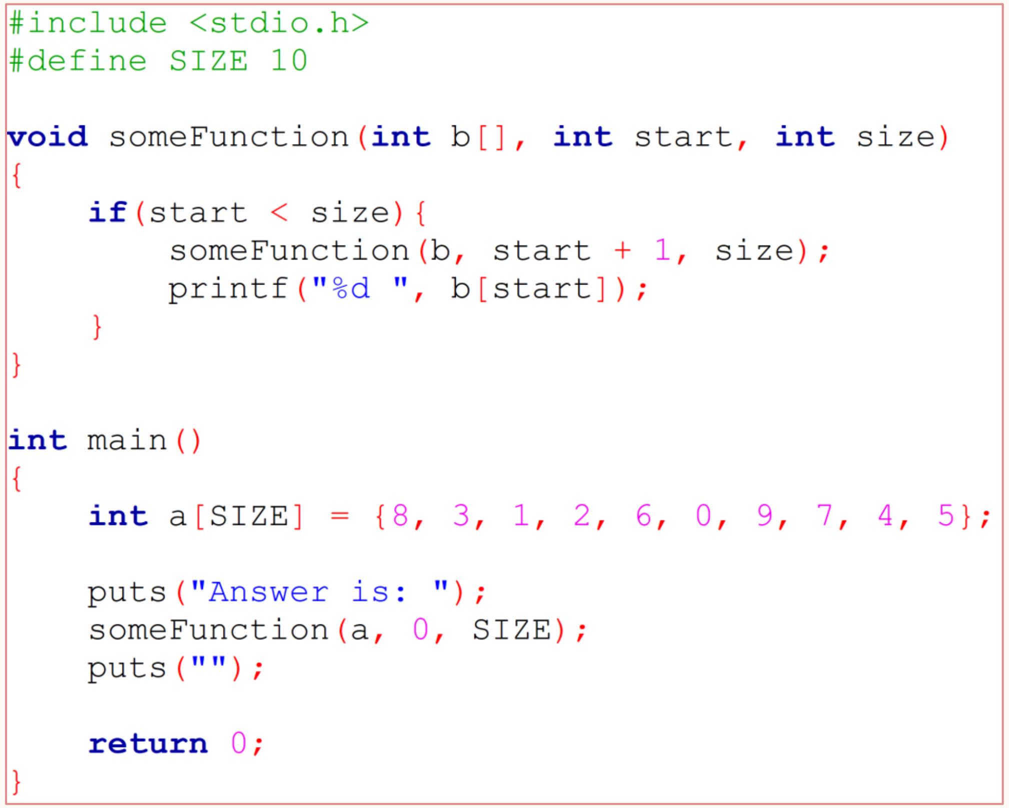
2. What does the following program do?



```
#include <stdio.h>
#define SIZE 10

int whatIsThis(int b[], int p)
{
    if(1 == p){
        return b[0];
    }
    else {
        return b[p - 1] + whatIsThis(b, p - 1);
    }
}

int main()
{
    int a[SIZE] = {1, 2, 3, 4, 5, 6, 7, 8, 9, 10};

    int x = whatIsThis(a, SIZE);
    printf("Result is %d\n", x);

    return 0;
}
```

EXERCISES

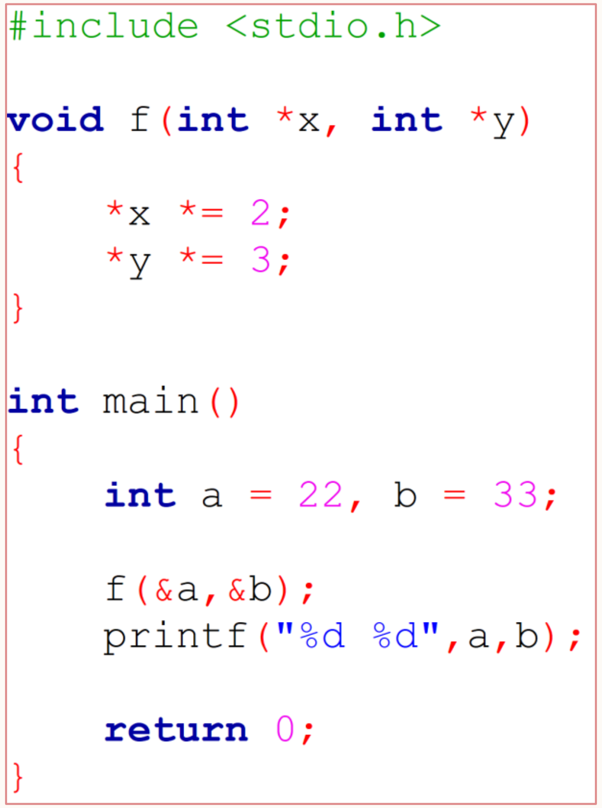
3. What does the following program do?



```c
#include <stdio.h>
#define SIZE 10

void someFunction(int b[], int start, int size)
{
    if(start < size){
        someFunction(b, start + 1, size);
        printf("%d ", b[start]);
    }
}

int main()
{
    int a[SIZE] = {8, 3, 1, 2, 6, 0, 9, 7, 4, 5};

    puts("Answer is: ");
    someFunction(a, 0, SIZE);
    puts("");

    return 0;
}
```

EXERCISES

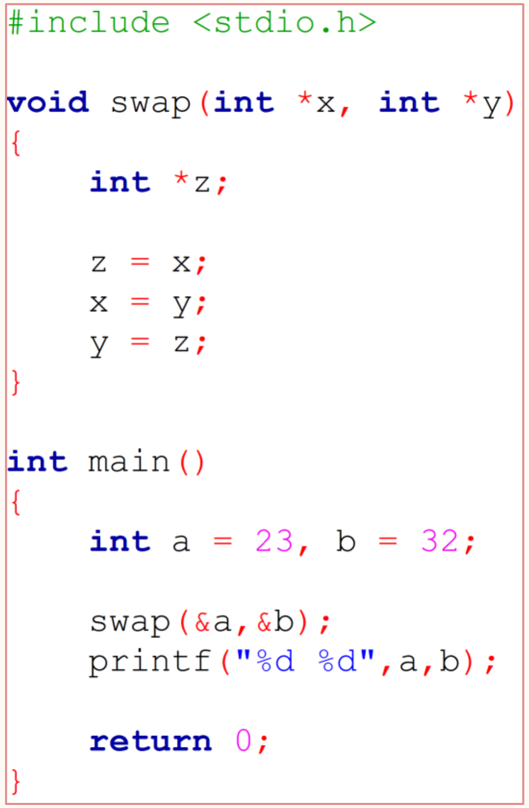
4. What is displayed by the following code?



```
#include <stdio.h>

void f(int *x, int *y)
{
    *x *= 2;
    *y *= 3;
}

int main()
{
    int a = 22, b = 33;

    f(&a,&b);
    printf("%d %d",a,b);

    return 0;
}
```

EXERCISES

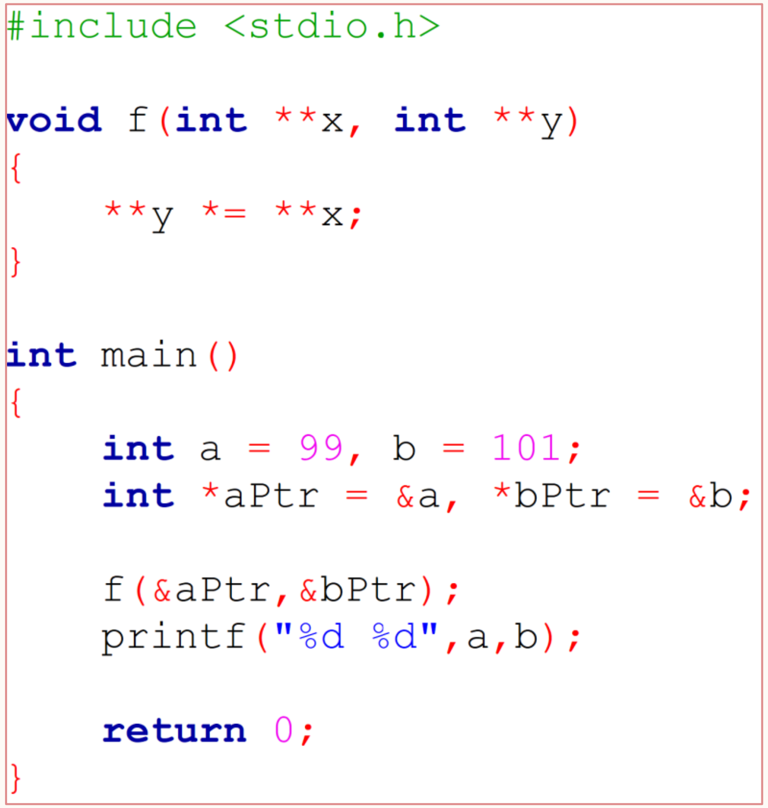
5. What is displayed by the following code?



```c
#include <stdio.h>

void swap(int *x, int *y)
{
    int *z;

    z = x;
    x = y;
    y = z;
}

int main()
{
    int a = 23, b = 32;

    swap(&a,&b);
    printf("%d %d",a,b);

    return 0;
}
```

EXERCISES

6. What is displayed by the following code?



```c
#include <stdio.h>

void f(int **x, int **y)
{
    **y *= **x;
}

int main()
{
    int a = 99, b = 101;
    int *aPtr = &a, *bPtr = &b;

    f(&aPtr,&bPtr);
    printf("%d %d",a,b);

    return 0;
}
```

EXERCISES

7. What, if anything, prints when each of the following C statements is performed? If the statement contains an error, describe the error and indicate how to correct it.

```
char s1[50] = “asterix”;
char s2[50] = “obelix”;
char s3[50] = “”;
```

a. `printf(“%c%s”, toupper(s1[0]), &s1[1]);`
b. `printf(“%s”, strcpy(s3,s2));`
c. `printf(“%s”, strcat(strcat(strcpy(s3,s1),“ and ”),s2));`
d. `printf(“%u”, strlen(s1) + strlen(s2));`

EXERCISES

8. Given these declarations.

```
char ssn[12] = “123-45-6789”;
char ssn1[4], ssn2[3], ssn3[5];
```

Write statements to accomplish the following.

a. Store in ssn1 the first three characters of ssn.
b. Store in ssn2 the middle two-digit portion of ssn.
c. Store in ssn3 the final four digits of ssn.

EXERCISES

9. Given the string name (value is “Adam, Bryan Zachary”) and the 40-character temporary variables tmp1 and tmp2, what string is displayed by the following code fragment?

```
strncpy(tmp1, &name[6], 5);
tmp1[5] = ‘\0’;
strcat(tmp1, “ ”);
strncpy(tmp2, name, 4);
tmp2[4] = ‘\0’;
printf(“%s\n”, strcat(tmp1, tmp2));
```

LAB

EXERCISES

1. Write a program that reads a line of text and prints the number of occurrences of each letter of the alphabet in the text.

```
Followers will never know how hard the leader tries to create path

a    4          n    2
b    0          o    5
c    1          p    1
d    2          q    0
e    9          r    6
f    1          s    2
g    0          t    5
h    4          u    0
i    2          v    1
j    0          w    4
k    1          x    0
l    5          y    0
m    0          z    0
```

EXERCISES

2. Write a program that reads a line of text and prints the number of one-letter words, two-letter words, three-letter words, and so on, appearing in the text.

```
Followers will never know how hard the leader tries to create path

Word Length        Occurrences
1                  0
2                  1
3                  2
4                  4
5                  2
6                  2
7                  0
8                  0
9                  1
```

EXERCISES

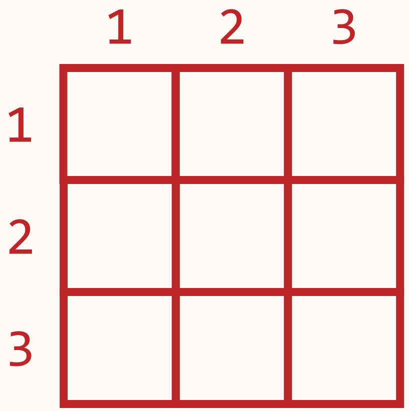
3. Write a program to play a game of tic-tac-toe.

   Input format: [row] [column] [X/O]

```
2 2 X
1 1 O
2 1 X
2 3 O
1 2 X
3 2 O
3 3 X
1 3 O
3 1 X

Draw
```

```
2 2 O
1 3 X
2 1 O
2 3 X
1 1 O
3 3 X

X wins
```

```
2 2 O
1 1 X
1 2 O
2 1 X
3 2 O

O wins
```



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- Thareja, R. (2014), Data Structures Using C (2nd Edition), India: Oxford University Press.

NEXT

Structures, Unions, & Enumerations:

Structures

Unions

Enumerations

VISION

To become an **outstanding** undergraduate Computer Science program that produces **international-minded** graduates who are **competent** in software engineering and have **entrepreneurial spirit** and **noble character**.

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1. To conduct studies with the best technology and curriculum, supported by professional lecturer
2. To conduct research in Informatics to promote science and technology
3. To deliver science-and-technology-based society services to implement science and technology

Without hard work,
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Have patience.
All things are difficult before they become easy.