POINTERS / ADDRESSES OF THE VARIABLES

Pointer → is a variable (or constant) that contains the address of another variable or address of any area in computer memory,
(e.g. it may be the address of a data or address of the program code)

The general form of the pointer definition:

type_of_data * pointerName ;

The most frequently used are „defined pointers, which contains information about:

- the **address** of the variable in the computer RAM memory
- the **type** of the data, stored in this variable

Examples of definitions:

```
int    * pointer;        // Pointer to an integer variable
double * ptr_number;     // Pointer to the real (double) variable
char   * ptr_char;       // Pointer to a single character
char   * text;           // Pointer to the beginning of the string
                            (the first sign of the text string)
```

We can also use the "undefined" (anonymous) pointers. Such pointer provides information only about the physical "address" → the beginning of the region (indicated without specifying the type of data)

Example definition:

void * pointerName ;

This is a pointer to any kind of data (the sequence of bytes).

There are two operators related to pointers / addresses:

- address-of operator (reference) **&** which returns an address (position in RAM memory) of the variable, or object
- indirection (dereference) operator ***** which returns the value of variable (or object) pointed by the address

```
int number ;
int *pointer ;
pointer = &number;      // assignment of the physical address
                        // of existing variable number

*pointer = 10;          // assignment of the value10 to memory area
                        // indicated by the pointer
                        // ( here, it i san equivalent of:  number = 10 )
```

Pointer Arithmetic

The list of operation which can be performer on pointers:

- assignment (=)

ptr = pointer_to_variable_or_any_memory_area ;
(in case of non-compliance types, the explicit type conversion is necessary)

- comparision operators (==, !=, <, >, <=, >=):

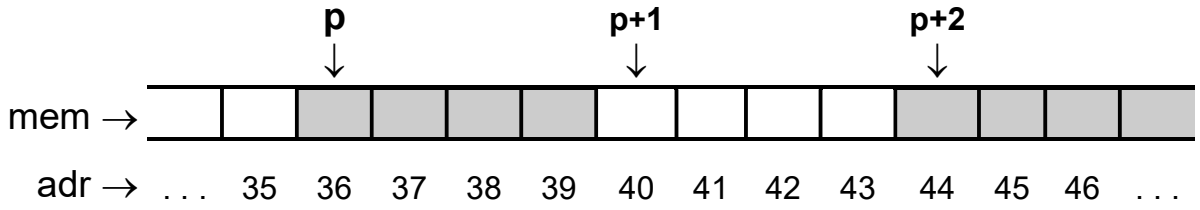
ptr_1 == ptr_2 // checking if variables contain the same addresses
ptr_1 < ptr_2 // check if variable **ptr_1** contains prior / smaller address
// than the address contained in variable/pointer **ptr_2**

- operations of incrementing or decrementing the pointer (+, –, ++, ––, +=, –=) by an integer number (applied only for "defined" pointers)

→ incrementing (or decrementing) the pointer by integer value **N** results in calculation of the address shifted by:

N ∗ sizeof(*type_of_pointed_area* **)**

bytes in the direction of increasing (decreasing) addresses.
np. **int ∗p**;



- subtracting of the two pointers (of the same type) → results in calculating the „distance" between two variables (areas in the memory) → number of objects

distance = (**N ∗ sizeof (** *type_of_pointed_area* **)** **)**

Examples of pointer variables:

```
int  *  ptr_number; // pointer to an integer number
int     tab_A[10];  // 10-element array of integers
                    ( identifier tab_A is the constant equal to the address
                      of the first element in this array
                      e.g.  tab_A == &( tab_A[0] )
int  *  tab_B[10];  // 10-element array of pointers
int  * ( tab_C[10] ); // the same as above
(int *)  tab_D[10];  // as above
int    (*tab_E)[10]; // pointer to 10-element array of integers
```

EXAMPLE-1: Access to variables using pointers

```
#include <stdio.h>
short  a ;      //  the smaller representation of integer data:  short ≡ short int
short  b ;      //  by default it takes 16 bits (2 bytes)
short  c ;
float   x ;
short * ptr ;
```

// example organization of memory


```
int main( )          // Illustration of accessing the variables,
{                    // by using different addresses combinations
                     // and pointer arithmetic

   // Printing the addresses of variables
   printf(" \n Address of variable A = %u " , (unsigned) &a ) ;          // 4203212
   printf(" \n Address of variable B = %u " , (unsigned) &b ) ;          // 4203214
   printf(" \n Address of variable C = %u " , (unsigned) &c ) ;          // 4203216
   printf(" \n Address of variable X = %u " , (unsigned) &x ) ;          // 4203220
   printf(" \n Address of variable PTR = %u " , (unsigned) &ptr ) ;      // 4203224

   a = b = c = 0;                    printf( " \n A=%d, B=%d, C=%d " , a, b, c ) ;

   b=10;                             printf( " \n A=%d, B=%d, C=%d " , a, b, c ) ;

   ptr = &b;
   *ptr = 20;                        printf( " \n A=%d, B=%d, C=%d " , a, b, c ) ;

   ptr = &a;
   *(ptr +1) = 30;                   printf( " \n A=%d, B=%d, C=%d " , a, b, c ) ;

   *(&a + 1) = 40;                   printf( " \n A=%d, B=%d, C=%d " , a, b, c ) ;

   *(&c – 1) = 50;                   printf( " \n A=%d, B=%d, C=%d " , a, b, c ) ;

   *( (short*)&x –3) = 60;           printf( " \n A=%d, B=%d, C=%d " , a, b, c ) ;

   *((short *)(&x –1) –1) = 70;      printf( " \n A=%d, B=%d, C=%d " , a, b, c ) ;

   *((short *)&ptr –5) = 80;         printf( " \n A=%d, B=%d, C=%d " , a, b, c ) ;

   *((short*)(&ptr –2) –1)= 90;      printf( " \n A=%d, B=%d, C=%d " , a, b, c ) ;

   getchar();
}
```

EXAMPLE-2: Accessing arrays with indexes and/or pointers

```
#include <stdio.h>                          // Common part of all examples on this page
#define   ARR_SIZE  10
int main(void)
{
   int arr[ ARR_SIZE ];
        //  ← the "loop", which is executing below listed operations:
            //  ← reading a number into an array
   • • •    //  ← multiplying an array element by 2
            //  ← display an element of the array
}
```

---

a)
```
int i;                          // accessing the elements of an array using the index operator
for( i = 0; i < ARR_SIZE; ++i )
   {
      scanf( "%d", & arr[ i ] );
      arr[ i ] = 2 * arr[ i ];                                   // arr[ i ] *= 2;
      printf( "Array[ %d ] = %d \n", i+1 , arr[ i ] );
   }
```

b)
```
int i;                                  // access by index and dereference operator
for( i = 0; i < ARR_SIZE; ++i )
   {
      scanf( "%d", arr+i );                                  // &*(arr+i) == arr+i
      *(arr+i) = 2 * *(arr+i);                               // *(arr+i) *= 2;
      printf( "Array[ %d ] = %d \n", i+1 , *(arr+i) );
   }
```

c)
```
int counter, *ptr;     // access using a pointer and dereference operator, (+counter)
for(  counter=0, ptr=arr;  counter < ARR_SIZE;  ++counter, ++ptr )
   {
      scanf( "%d", ptr );
      *ptr = 2* *ptr;      // *ptr *= 2;
      printf( "Array[ %d ] = %d \n", counter+1 , *ptr );
   }
```

d)
```
int *ptr;                               // access using only pointers (no additional counter)
for(  ptr=arr;  ptr < arr + ARR_SIZE;  ++ptr )
   {                                    // ptr < &arr[ARR_SIZE]   ← pointer to „end of array"
      scanf( "%d", ptr );
      *ptr *= 2;
      printf( "Array [ %d ] = %d \n", ptr–arr+1 , *ptr );
   }
```