

## STRUCTURES IN C/C++

- struct** → The most **flexible** way to represent data in C language (equivalent to a record in Pascal, or tuple ),
- a **user-defined**, complex data type declaration that defines a physically **grouped list** of variables
  - a group of variables (could combine **different types**), placed under one name, in a one **contiguous block** of memory, accessed via a **single name** or single pointer,

### Definition of a new structural type:

```
struct name_of_new_type           ← name of the created structure
{
    type_name_1  field_name_1;
    type_name_2  field_name_2;    ← types and names of fields
    . . .
    type_name_n  field_name_n;
};
```

### Example:

Kowalski	Jan	1987	173 cm	'm'	437.20zł
family_name	name	birth_year	height	gender	scholarship
char [30]	char [15]	short	short	char	double

```
struct TPersonalData
{
    char    family_name [30];
    char    name [15];
    short   birth_year, height;
    char    gender;
    double  scholarship;
};

struct TCalendarDate { int day, month, year; };

struct TLoan
{
    double    amount;
    char      description [50];
    TCalendarDate loan_date;           // nested structure
    TCalendarDate payback_date;       // nested structure
};
```

## Reserving / defining variables:

```
struct name_of_struct_type name_of_new_variable; // C
name_of_struct_type name_of_new_variable; // C++
```

### Examples:

```
TPersonalData student_1;
TPersonalData student_2, student_3, new_student;
TPersonalData student_group [ 20 ];

TLoan loan_for_Thomas;
TLoan my_loans [ 100 ];
```

### We can connect the variable definition and its initialization, Eg.:

```
// { family_name, name, birth_year, height, gender, scholarship }
TPersonalData student_x = {"Kowalski", "Jan", 1970, 175, 'M', 320.00 };

// { amount, description, { day, month, year }, { day, month, year } }
TLoan loan_x = { 100.00, "fee per apartment", {27,11,2006}, {3,12,2006}};
```

### We can combine definition of **new type** and definition of **new variable**:

```
struct new_type_name                               ← this type name could be omitted
{
    type_name_1  field_name_1;
    type_name_2  field_name_2;                       ← definitions of fields
    • • •
    type_name_n  field_name_n;
} new_variable ;                                   ← name of a new variable
```

Eg.

```
struct                                             // ← skipped type name
{
    char family_name [30];
    char name [15];
    short birth_year, height;
    char gender;
    double scholarship;
} student_1, student_2;                          // definition of two new variables / instances
```

## Accessing the structure members: with a dot operator

Examples:

```
student_1.height = 180 ; // assignment of numerical data
student_2.height = student_1.height;

loan_for_Thomas.amount = 50.00;
loan_for_Thomas.payback_date.month = 12;

scanf( "%lf" , &student.scholarship ); // input of a numerical data
scanf( "%s" , student.family_name ); // input a C-string char[ ]

cin >> student.scholarship;
cin >> student.family_name;

strcpy( student.name, "Thomas" ); // copying the C-string into a structure field
```

In the original version of the C language (Kernighan, Ritchie), the only operations permitted on the structure were: “the address of operator” (&) and accessing the components/fields/members with a dot operator.

In the C ++, it is also possible to directly assign (copy) all structure content, to pass the structure as the parameter to function, or return struct as a result.

```
memcpy( &student_2, &student_1, sizeof(student_1) ); // the only way in C !
student_2 = student_1; // direct assignment of struct, introduced in C++
student_2.family_name = student_1.family_name; // attention! char [ ]
strcpy( student_2.family_name, student_1.family_name );
```

```
 // function which returns a struct
TPersonalData Read_New_Personal_Data ( void )
{
    TPersonalData new_data;
    printf( "Enter family name: " );
    scanf( "%s" , new_data.family_name );
    . . .
    return new_data ;
}

 // function which receives the struct as an argument
void Display_Personal_Data ( const TPersonalData &person )
{ // or alternatively a copy: ( TPersonalData person )
    printf( "Family name: %s\n" , person.family_name );
    printf( "      Name: %s\n" , person.name );
    . . .
}
```

## Struct as an element of Array:

```
TPersonalData empty_struct_array [ 100 ];    // definitions of struct arrays

TPersonalData database[ 3 ] = {
    { "Kowalski", "Jan", 1970, 175, 'm', 95.00 } ,
    { "Nowak", "Tomasz", 1965, 180, 'm', 0.00 } ,
    { "Nowak", "Anna", 1983, 162, 'k', 250.0 } };

database [0].height = 175;                    // example operations of database fields
database [1].family_name[0] = 'N';
strcpy( database[2].name, "Anna" );
```

	family name	name	birth date	height	gender	scholarship
0	Kowalski	Jan	1970	175	'm'	95.00
1	Nowak	Tomasz	1965	180	'm'	0.00
2	Nowak	Anna	1983	162	'k'	250.00

```
for( int i = 0; i < 3; i++ )                // display the all content of a "database"
{
    printf( "Person no [%d] \n" , i+1 );
    printf( "Family name: %s \n" , database [ i ].family_name );
    . . .
    printf( "Scholarship: %.2f \n" , database [ i ].scholarship );
}
```

**Pointers to struct:** an 'arrow' operator **->** to access the struct members

```
TPersonalData student;
student.height = 180;                        // direct assignment to struct member field

TPersonalData *ptr_person;                 // a pointer to struct
ptr_person = &student;

(*ptr_person).height = 180;                // traditional notation using * 'star' operator
ptr_person->height = 180;                   // the same with an 'arrow' operator

cin >> database[ 2 ].scholarship;          // scanf("%lf",&(database[2].scholarship) );
cin >> (database+2)->scholarship;          // scanf("%lf",&((database+2)->scholarship));

for(ptr_person =database; ptr_person <database+3; ptr_person ++ )
    cin >> ptr_person ->scholarship;
```

## Example 1 : loading / viewing / filtering the list of loans

```
#include <iostream> // implementation in C++
struct TCalendarDate { int day, month, year; };

struct TLoan { double amount; char description[50];
              TCalendarDate loan_date, payback_date;};

const int N=10;
TLoan my_loans [N];

int main()
{
    cout<<"Please enter the data of your loans:";
    for(int i=0; i<N; i++) {
        cout<<"\n\nLoan number "<< i <<endl;
        cout<<"Amount in PLN = ";    cin>>my_loans[i].amount;
        cout<<"Description = ";      cin>>my_loans [i].description;
        cout<<"Date of loan:\n";
        cout<<"  day = ";            cin>>my_loans[i].loan_date.day;
        cout<<"  month = ";          cin>>my_loans[i].loan_date.month;
        cout<<"  year = ";           cin>>my_loans[i].loan_date.year;
    }

    cout<<"\n\nDisplaying the full list of entered loans:";
    for(int i=0; i<N; i++) {
        cout<<"\n\nLoan number "<< i <<endl;
        cout<<"Amount in PLN = "<< my_loans[i].amount ;
        cout<<" Description = "<< my_loans [i].description;
        cout<<"\nDate of loan: "<< my_loans[i].loan_date.day <<"/";
        cout<< my_loans[i].loan_date.month<<"/";
        cout<< my_loans[i].loan_date.year;
    }

    cout<<"\n\nDisplaying only the big loans (greater than 100PLN): ";
    for(int i=0; i<N; i++)
        if(my_loans[i].amount >100 ) {
            cout<<"\n\nLoan number "<< i <<endl;
            cout<<"Amount in PLN = "<< my_loans[i].amount ;
            cout<<" Description = "<< my_loans [i].description;
            cout<<"\nDate of loan: "<< my_loans[i].loan_date.day <<"/";
            cout<< my_loans[i].loan_date.month<<"/";
            cout<< my_loans[i].loan_date.year;
        }

    cout<<"\n\nEnd of the program. Press ENTER to close the console";
    cin.ignore(); cin.get();
    return 0;
}
```

## Example 2 : Another version of Example no 1 → using the functions

```
#include <iostream> // implementation in C++

// --- definition of calendar date struct and functions READ / DISPLAY ---

struct TCalendarDate { int day, month, year; };

void READ_DATE(TCalendarDate & date)
{
    cout<<" day   = ";    cin>>date.day;
    cout<<" month = ";    cin>>date.month;
    cout<<" year  = ";    cin>>date.year;
}

void DISPLAY_DATE(const TCalendarDate & date)
{
    cout<<date.day<<"/"<<date.month<<"/"<<date.year;
}

// ----- definition of loan struct and functions READ / DISPLAY for loans -----

struct TLoan { double amount; char description [50];
              TCalendarDate loan_date, payback_date;};

void READ_LOAN (TLoan & loan)
{
    cout<<"Amount   = "; cin>>loan.amount;
    cout<<"Description = "; cin>>loan.description;
    cout<<"Loan date:\n";
    READ_DATE( loan.loan_date );
    cout<<"Date of payback:\n";
    READ_DATE( loan.payback_date );
}

void DISPLAY_LOAN(const TLoan & loan)
{
    cout << "Amount = " << loan.amount;
    cout << " Description = " << loan.description;
    cout << "\nLoan date: ";
    DISPLAY_DATE( loan.loan_date );
    cout << "\nDate of payback: ";
    DISPLAY_DATE ( loan.payback_date );
}
```

. . . continuation of example (2)

```
// ----- Main program -----  
// ----- Using just defined structures and functions -----  
  
// TCalendarDate / READ_DATE / DISPLAY_DATE  
// TLoan / READ_LOAN / DISPLAY_LOAN  
  
const int N=10;  
TLoan my_loans[N];  
  
int main()  
{  
    cout<<" Please enter the data of your loans:";  
    for(int i=0; i<N; i++)  
        {  
            cout<<"\n\nLoan number "<< i <<endl;  
            READ_LOAN( my_loans [i] );  
        }  
  
    cout<<"\n\n Displaying the full list of entered loans: ";  
    for(int i=0; i<N; i++)  
        {  
            cout<<"\n\nLoan number "<<i<<endl; ~~~~~  
            DISPLAY_LOAN( my_loans [i] );  
        }  
  
    cout<<"\n\nDisplaying only the big loans (greater than 100PLN).:";  
    for(int i=0; i<N; i++)  
        if( my_loans[i].amount>100 )  
            {  
                cout<<"\n\nLoan number "<< i <<endl; ~~~~~  
                DISPLAY_LOAN( my_loans[i] );  
            }  
  
    cout<<"\n\n nEnd of the program. Press ENTER to close the console";  
    cin.ignore(); cin.get();  
    return 0;  
}
```