

# ENPM691 Homework 1:Measuring Memory Size of C Data Type

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**Abstract**—This report presents a method to measure memory sizes and alignment of common C data types (`char`, `short`, `int`, `long`, `long long`, `float`, `double`, `long double` and their unsigned versions) without using the `sizeof()` operator. A struct-based method is used to compute sizes by subtracting memory addresses. Results are verified against `sizeof()` and discussed.

**Index Terms**—C programming, data types, memory alignment, `sizeof`, struct method

## I. PURPOSE

This assignment aims to investigate basic memory organization concepts in C programming, with a particular emphasis on variable size and alignment. To determine the number of bytes for common variable types like `int`, `long`, `float`, `double`, and others, a C program was created. The main measurement technique entails building structures and examining the address differences between members. The built-in `sizeof()` operator is used to validate the results. The methodology, findings and a detailed discussion of the results, including any discrepancies caused by the padding imposed by the compiler, are provided in this report.

## II. METHOD

- Create a struct containing two variables of the same type.
- Subtract the addresses of the two variables to determine the size of the type:  

$$(\text{char}^*)\&s.\text{b} - (\text{char}^*)\&s.\text{a}$$
- Repeat for all signed and unsigned integer types, as well as floating-point types.
- Verify each measurement using `sizeof()`.

## III. RESULTS

Table I shows measured sizes of various data types using the struct method and `sizeof()` for verification. It also includes typical Linux 64-bit sizes for comparison.

## IV. DISCUSSION

The outcomes of the struct-based approach closely resemble the sizes found using the built-in `sizeof()` operator, proving that calculating the memory size of variables in C can be done with accuracy by measuring the address differences between struct members. This demonstrates that the struct method can

TABLE I  
DATA TYPE SIZES (STRUCT METHOD VS `SIZEOF()`) ON WINDOWS 64-BIT AND LINUX 64-BIT

Type	Struct Method (Windows)	<code>sizeof()</code> (Windows)	Struct Method (Linux)	<code>sizeof()</code> (Linux)
<code>char</code>	1	1	1	1
unsigned <code>char</code>	1	1	1	1
<code>short</code>	2	2	2	2
unsigned <code>short</code>	2	2	2	2
<code>int</code>	4	4	4	4
unsigned <code>int</code>	4	4	4	4
<code>long</code>	4	4	8	8
unsigned <code>long</code>	4	4	8	8
<code>long long</code>	8	8	8	8
unsigned <code>long long</code>	8	8	8	8
<code>float</code>	4	4	4	4
<code>double</code>	8	8	8	8
<code>long double</code>	16	16	16	16

be used as a substitute for `sizeof()` in situations where it is prohibited or for teaching purposes to comprehend memory layout.

The findings allow for the following observations:

- **Integer types:** The same number of bytes are occupied by signed and unsigned integer types (`char`, `short`, `int`, `long`, and `long long`). The range of values that signed and unsigned types can store is the only distinction between them; memory size is not.
- **Floating-point types:** Because their representation by default contains a sign bit, the floating-point types (`float`, `double`, and `long double`) do not have unsigned variants. Their usual sizes are four bytes for `float`, eight bytes for `double`, and sixteen bytes for `long double` on the majority of 64-bit systems—were validated by the struct method.
- **Memory alignment and padding:** The struct-based approach sheds light on memory alignment as well. In order to guarantee effective access, compiler-imposed padding may be used to align data structures on memory boundaries. This is especially evident for larger data types, such as `long double`, where alignment may result in a greater member difference than is strictly required for the type size.
- **Platform dependence:** Depending on the compiler and operating system, some types' sizes, particularly those of `long` and `long double`, may change. For instance, `long` is typically 4 bytes on Windows 64-bit systems and 8 bytes on Linux 64-bit systems. This highlights how crucial it is to check sizes when writing portable C code.
- **Address computation and format specifiers:** The num-

ber of bytes between two members can be found by casting the addresses to `char*` and subtracting them when utilizing the `struct` method. Accurate printing and the avoidance of undefined behavior depend on using the proper format specifiers (`%ld` for the difference, `%zu` for `sizeof()`).

- **Comprehending memory organization:** This practice helps reinforce important ideas in C programming, such as the function of compiler padding, the effect of data type alignment, and how variables are stored in memory. It also emphasizes how basic operations, like pointer arithmetic, can be used to examine memory layouts without the need for built-in functions.

All things considered, this task gave practical experience in comprehending memory alignment, variable size, and platform-dependent behavior of C data types. It proved that combining `sizeof()` with struct-based address calculations provides a thorough method of verifying memory organization in C programs.

## V. APPENDIX: C PROGRAM

```

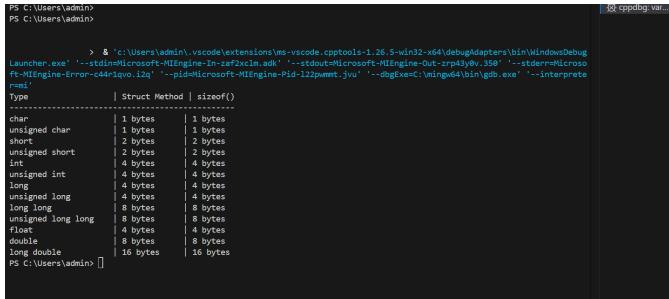
1 #include <stdio.h>
2
3 // creating struct for signed char, short, int, long
4 // and long long.
5 struct CharStruct { char a, b; };
6 struct ShortStruct { short a, b; };
7 struct IntStruct { int a, b; };
8 struct LongStruct { long a, b; };
9 struct LongLongStruct { long long a, b; };
10
11 // creating struct for unsigned char, short, int,
12 // long and long long.
13 struct UCharStruct { unsigned char a, b; };
14 struct UShortStruct { unsigned short a, b; };
15 struct UIntStruct { unsigned int a, b; };
16 struct ULongStruct { unsigned long a, b; };
17 struct ULongLongStruct { unsigned long long a, b; };
18
19 // creating struct for float, double, longdouble.
20 struct FloatStruct { float a, b; };
21 struct DoubleStruct { double a, b; };
22 struct LongDoubleStruct { long double a, b; };
23
24 int main() {
25
26     struct CharStruct sc;           // creating a
27     struct UCharStruct suc;         // creating a
28     struct ShortStruct ss;          // creating a
29     struct UShortStruct sus;        // creating a
30     struct IntStruct si;           // creating a
31     struct UIntStruct sui;          // creating a
32     struct LongStruct sl;           // creating a
33     struct ULongStruct sul;         // creating a
34     struct LongLongStruct sll;       // creating a
35     struct ULongLongStruct sull;      // creating a
36
37     struct DoubleStruct sd;         // creating a
38     struct LongDoubleStruct sld;      // creating a
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79 }
```

```

struct DoubleStruct sd;           // creating a
                                struct variable of DoubleStruct
struct LongDoubleStruct sld;      // creating a
                                struct variable of LongDoubleStruct
/*Printing the difference between the address of
two same datatype from the struct
and seeing if the difference is same which we
get from sizeof function and forming
it in a tabular form for easy viewing.*/
printf("Type_____|_Struct_Method_|_
 sizeof()\n");
printf("-----\n");
printf("char_____|_%ld_bytes_|_
 %zu_bytes\n",
      (long)((char*)&sc.b - (char*)&sc.a),
      sizeof(char));
printf("unsigned_char_____|_%ld_bytes_|_
 %zu_bytes\n",
      (long)((char*)&suc.b - (char*)&suc.a),
      sizeof(unsigned char));
printf("short_____|_%ld_bytes_|_
 %zu_bytes\n",
      (long)((char*)&ss.b - (char*)&ss.a),
      sizeof(short));
printf("unsigned_short_____|_%ld_bytes_|_
 %zu_bytes\n",
      (long)((char*)&sus.b - (char*)&sus.a),
      sizeof(unsigned short));
printf("int_____|_%ld_bytes_|_
 %zu_bytes\n",
      (long)((char*)&si.b - (char*)&si.a),
      sizeof(int));
printf("unsigned_int_____|_%ld_bytes_|_
 %zu_bytes\n",
      (long)((char*)&sui.b - (char*)&sui.a),
      sizeof(unsigned int));
printf("long_____|_%ld_bytes_|_
 %zu_bytes\n",
      (long)((char*)&sl.b - (char*)&sl.a),
      sizeof(long));
printf("unsigned_long_____|_%ld_bytes_|_
 %zu_bytes\n",
      (long)((char*)&sul.b - (char*)&sul.a),
      sizeof(unsigned long));
printf("long_long_____|_%ld_bytes_|_
 %zu_bytes\n",
      (long)((char*)&sll.b - (char*)&sll.a),
      sizeof(long long));
printf("unsigned_long_long_____|_%ld_bytes_|_
 %zu_bytes\n",
      (long)((char*)&sull.b - (char*)&sull.a),
      sizeof(unsigned long long));
printf("float_____|_%ld_bytes_|_
 %zu_bytes\n",
      (long)((char*)&sf.b - (char*)&sf.a),
      sizeof(float));
printf("double_____|_%ld_bytes_|_
 %zu_bytes\n",
      (long)((char*)&sd.b - (char*)&sd.a),
      sizeof(double));
printf("long_double_____|_%ld_bytes_|_
 %zu_bytes\n",
      (long)((char*)&sld.b - (char*)&sld.a),
      sizeof(long double));
return 0;

```

Listing 1. C program to measure C data type sizes using structs



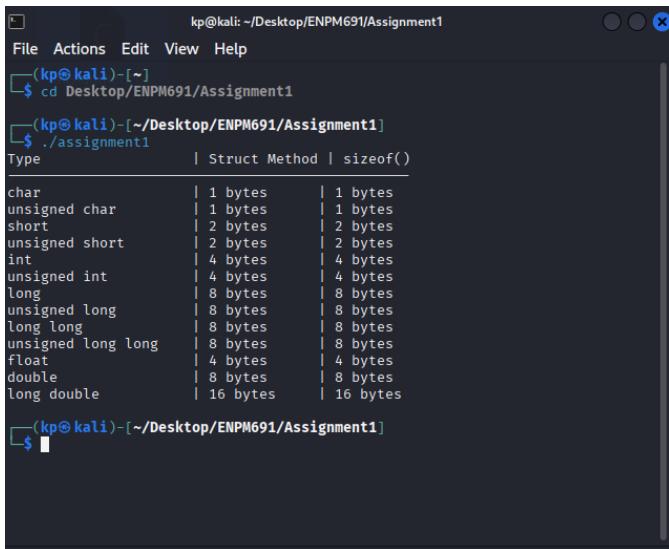
```

PS C:\Users\admin>
PS C:\Users\admin>

> & "c:\Users\admin\vscode\extensions\ms-vscode.cpptools-1.26.5-win32-x64\debugAdapters\b1n\WindowsDebug
Launcher.exe" '--std=iso9899:2011' '--cStandard=ISO_C99' '--cppStandard=ISO_CPP03' '--targetPlatform=Windows'
--targetArchitecture=x64 --targetOS=Windows --targetVersion=10 --targetProcessor=x64 --targetFile=C:\mingw64\bin\gdb.exe" --interpret
Type           | Struct Method | sizeof()
-----|-----|-----
char          | 1 bytes      | 1 bytes
unsigned char | 1 bytes      | 1 bytes
short          | 2 bytes      | 2 bytes
unsigned short | 2 bytes      | 2 bytes
int            | 4 bytes      | 4 bytes
unsigned int   | 4 bytes      | 4 bytes
long           | 4 bytes      | 4 bytes
unsigned long  | 4 bytes      | 4 bytes
long long      | 8 bytes      | 8 bytes
unsigned long long | 8 bytes      | 8 bytes
float          | 4 bytes      | 4 bytes
double         | 8 bytes      | 8 bytes
long double    | 16 bytes     | 16 bytes
PS C:\Users\admin> []

```

Fig. 1. Program output showing data type sizes using the struct method and sizeof() when the C program is compiled and executed on a Windows 64-bit operating system.



```

kp@kali: ~/Desktop/ENPM691/Assignment1
File Actions Edit View Help
(kp@kali)-[~]
$ cd Desktop/ENPM691/Assignment1
(kp@kali)-[~/Desktop/ENPM691/Assignment1]
$ ./assignment1
Type           | Struct Method | sizeof()
-----|-----|-----
char          | 1 bytes      | 1 bytes
unsigned char | 1 bytes      | 1 bytes
short          | 2 bytes      | 2 bytes
unsigned short | 2 bytes      | 2 bytes
int            | 4 bytes      | 4 bytes
unsigned int   | 4 bytes      | 4 bytes
long           | 8 bytes      | 8 bytes
unsigned long  | 8 bytes      | 8 bytes
long long      | 8 bytes      | 8 bytes
unsigned long long | 8 bytes      | 8 bytes
float          | 4 bytes      | 4 bytes
double         | 8 bytes      | 8 bytes
long double    | 16 bytes     | 16 bytes
(kp@kali)-[~/Desktop/ENPM691/Assignment1]
$ 

```

Fig. 2. Program output showing data type sizes using the struct method and sizeof() when the C program is compiled and executed on a Linux 64-bit system.