

Лабораторная работа №13

Операционные системы

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6 мая 2023

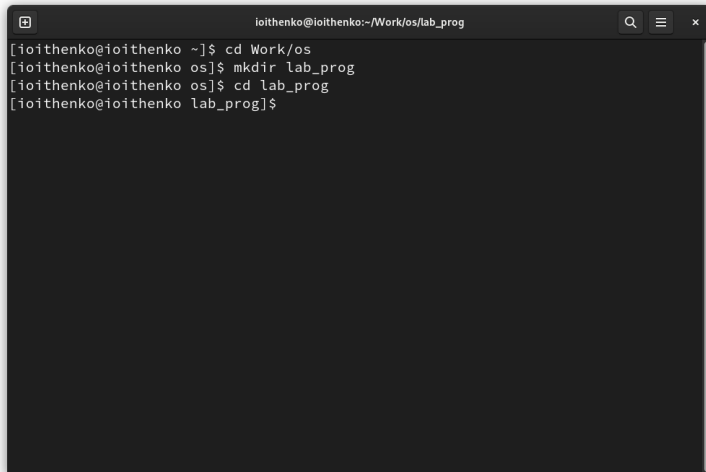
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- НПИбд-01-22

Приобрести простейшие навыки разработки, анализа, тестирования и отладки приложений в ОС типа UNIX/Linux на примере создания на языке программирования С калькулятора с простейшими функциями.

Выполнение лабораторной работы

Выполнение лабораторной работы

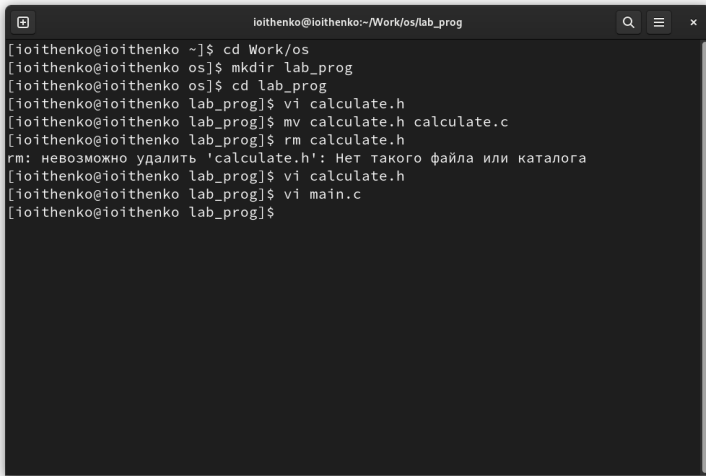
A terminal window with a dark background. The title bar at the top reads 'ioithenko@ioithenko:~/Work/os/lab_prog'. The terminal shows a sequence of commands: first, 'cd Work/os' is entered, then 'mkdir lab_prog' is entered, and finally 'cd lab_prog' is entered. The prompt changes from '~]' to 'os]' and then to 'lab_prog]' as the user navigates through the directory structure.

```
ioithenko@ioithenko:~/Work/os/lab_prog
[ioithenko@ioithenko ~]$ cd Work/os
[ioithenko@ioithenko os]$ mkdir lab_prog
[ioithenko@ioithenko os]$ cd lab_prog
[ioithenko@ioithenko lab_prog]$
```

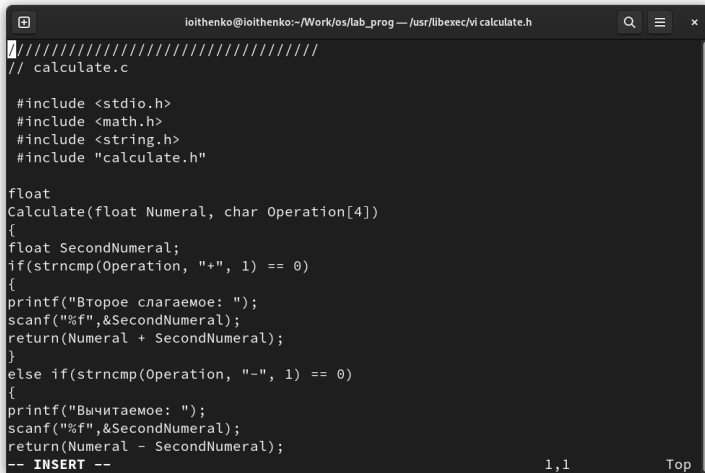
Рис. 1: Создание поддиректории ~/work/os/lab_prog.

Выполнение лабораторной работы

Создаю файлы `calculate.h`, `calculate.c`, `main.c` и заполняю их, согласно описанию лабораторной работы:



```
ioithenko@ioithenko:~/Work/os/lab_prog
[ioithenko@ioithenko ~]$ cd Work/os
[ioithenko@ioithenko os]$ mkdir lab_prog
[ioithenko@ioithenko os]$ cd lab_prog
[ioithenko@ioithenko lab_prog]$ vi calculate.h
[ioithenko@ioithenko lab_prog]$ mv calculate.h calculate.c
[ioithenko@ioithenko lab_prog]$ rm calculate.h
rm: невозможно удалить 'calculate.h': Нет такого файла или каталога
[ioithenko@ioithenko lab_prog]$ vi calculate.h
[ioithenko@ioithenko lab_prog]$ vi main.c
[ioithenko@ioithenko lab_prog]$
```



```
ioithenko@ioithenko:~/Work/os/lab_prog — /usr/libexec/vi calculate.h
// calculate.c

#include <stdio.h>
#include <math.h>
#include <string.h>
#include "calculate.h"

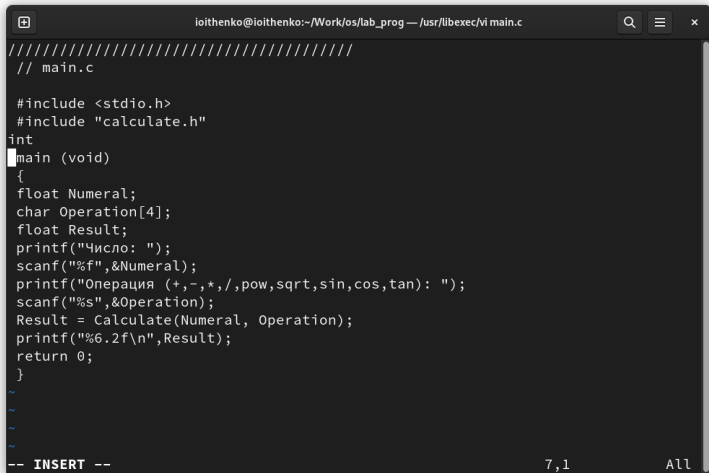
float
Calculate(float Numeral, char Operation[4])
{
    float SecondNumeral;
    if(strncmp(Operation, "+", 1) == 0)
    {
        printf("Второе слагаемое: ");
        scanf("%f",&SecondNumeral);
        return(Numeral + SecondNumeral);
    }
    else if(strncmp(Operation, "-", 1) == 0)
    {
        printf("Вычитаемое: ");
        scanf("%f",&SecondNumeral);
        return(Numeral - SecondNumeral);
    }
    -- INSERT --
1,1 Top
```

Рис. 3: Содержимое файла calculate.c.

[illegible]

Рис. 4: Содержимое файла calculate.h.

Выполнение лабораторной работы



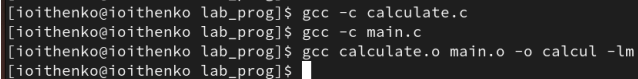
```
ioithenko@ioithenko:~/Work/os/lab_prog — /usr/libexec/vi main.c
////////////////////////////////////
// main.c

#include <stdio.h>
#include "calculate.h"
int
main (void)
{
    float Numeral;
    char Operation[4];
    float Result;
    printf("Число: ");
    scanf("%f",&Numeral);
    printf("Операция (+,-,*,/,pow,sqrt,sin,cos,tan): ");
    scanf("%s",&Operation);
    Result = Calculate(Numeral, Operation);
    printf("%.2f\n",Result);
    return 0;
}

~
~
~
-- INSERT --                               7,1                               All
```

Рис. 5: Содержимое файла main.c.

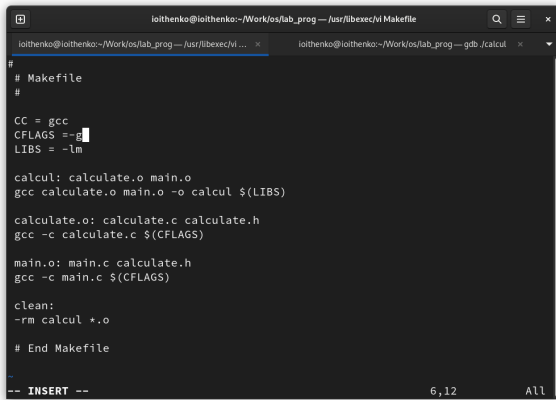
3. Выполняю компиляцию программы посредством gcc:

A terminal window with a dark background and light-colored text. It shows four lines of commands being executed in a directory named 'lab_prog'. The first two lines compile 'calculate.c' and 'main.c' separately using 'gcc -c'. The third line links the resulting object files 'calculate.o' and 'main.o' into an executable named 'calcul' using 'gcc calculate.o main.o -o calcul -lm'. The fourth line shows the prompt without a command.

```
[ioithenko@ioithenko lab_prog]$ gcc -c calculate.c  
[ioithenko@ioithenko lab_prog]$ gcc -c main.c  
[ioithenko@ioithenko lab_prog]$ gcc calculate.o main.o -o calcul -lm  
[ioithenko@ioithenko lab_prog]$
```

Рис. 6: Компиляция программы.

4. Создаю. Makefile с содержанием, согласно описанию лабораторной работы, при этом немного изменяю его:



```
ioithenko@ioithenko:~/Work/os/lab_prog — /usr/libexec/vi Makefile
ioithenko@ioithenko:~/Work/os/lab_prog — /usr/libexec/vi ...
ioithenko@ioithenko:~/Work/os/lab_prog — gdb ./calcul

# Makefile
#

CC = gcc
CFLAGS = -g
LIBS = -lm

calcul: calculate.o main.o
gcc calculate.o main.o -o calcul $(LIBS)

calculate.o: calculate.c calculate.h
gcc -c calculate.c $(CFLAGS)

main.o: main.c calculate.h
gcc -c main.c $(CFLAGS)

clean:
-rm calcul *.o

# End Makefile

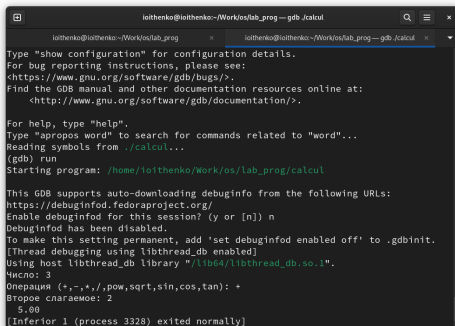
-- INSERT --
6,12 All
```

Рис. 7: Содержимое Makefile.

5. С помощью gdb выполняю отладку программы calcul:

Запускаю отладчик GDB, загрузив в него программу для отладки.

Запускаю программу внутри отладчика, введя команду run:



```
ioithenko@ioithenko:~/Work/os/lab_prog — gdb ./calcul
Type "show configuration" for configuration details.
For bug reporting instructions, please see:
<https://www.gnu.org/software/gdb/bugs/>.
Find the GDB manual and other documentation resources online at:
<http://www.gnu.org/software/gdb/documentation/>.

For help, type "help".
Type "apropos word" to search for commands related to "word"...
Reading symbols from ./calcul...
(gdb) run
Starting program: /home/ioithenko/Work/os/lab_prog/calcul

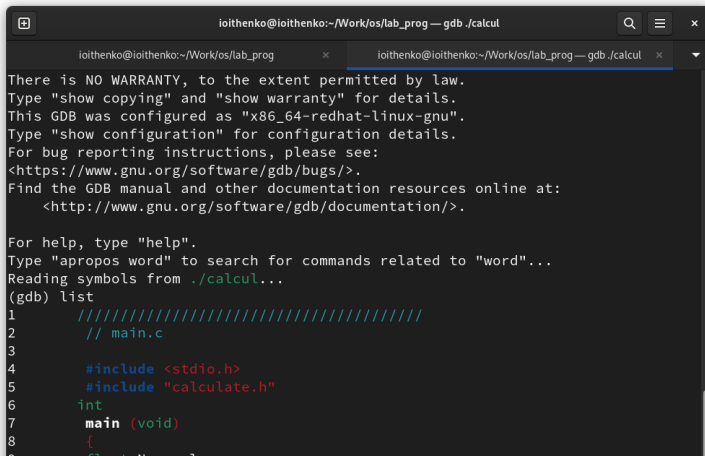
This GDB supports auto-downloading debuginfo from the following URLs:
https://debuginfod.fedoraproject.org/
Enable debuginfod for this session? (y or [n]) n
Debuginfod has been disabled.
To make this setting permanent, add 'set debuginfod enabled off' to .gdbinit.
[Thread debugging using libthread_db enabled]
Using host libthread_db library "/lib64/libthread_db.so.1".
Число: 3
Операция (+,-,*,/,pow,sqrt,sin,cos,tan): +
Второе слагаемое: 2
5.00
[Inferior 1 (process 3328) exited normally]
```

Рис. 8: Запуск отладчика и программы внутри отладчика.

Выполнение лабораторной работы

Постранично просматриваю исходный код с помощью команды `list`.

Просматриваю строки с 12 по 15 основного файла с помощью команды `list` с параметрами:

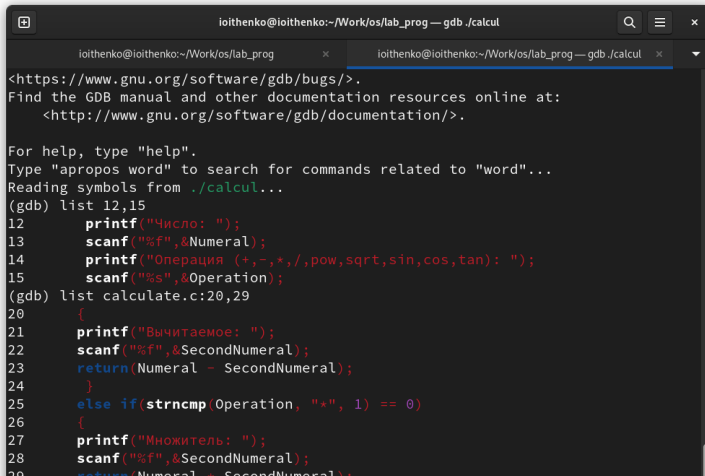


```
ioithenko@ioithenko:~/Work/os/lab_prog — gdb ./calcul
ioithenko@ioithenko:~/Work/os/lab_prog x ioithenko@ioithenko:~/Work/os/lab_prog — gdb ./calcul x
There is NO WARRANTY, to the extent permitted by law.
Type "show copying" and "show warranty" for details.
This GDB was configured as "x86_64-redhat-linux-gnu".
Type "show configuration" for configuration details.
For bug reporting instructions, please see:
<https://www.gnu.org/software/gdb/bugs/>.
Find the GDB manual and other documentation resources online at:
  <http://www.gnu.org/software/gdb/documentation/>.

For help, type "help".
Type "apropos word" to search for commands related to "word"...
Reading symbols from ./calcul...
(gdb) list
1      //////////////////////////////////////
2      // main.c
3
4      #include <stdio.h>
5      #include "calculate.h"
6      int
7      main (void)
8      {
9      }
```

Выполнение лабораторной работы

Просматриваю определённые строки не основного файла с помощью команды `list` с параметрами:

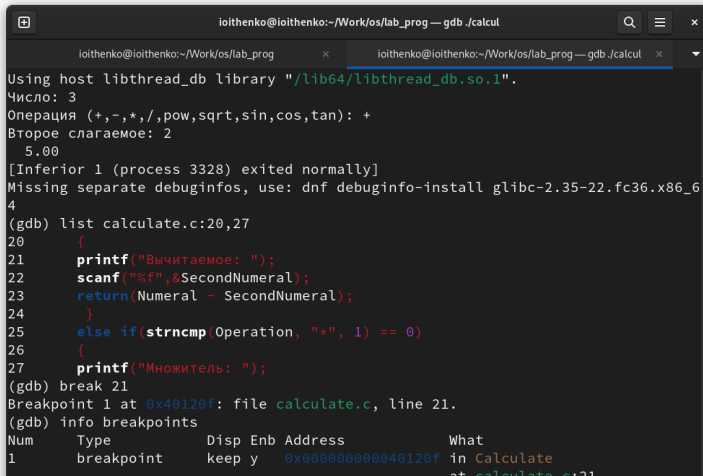


```
ioithenko@ioithenko:~/Work/os/lab_prog — gdb ./calcul
ioithenko@ioithenko:~/Work/os/lab_prog × ioithenko@ioithenko:~/Work/os/lab_prog — gdb ./calcul ×
<https://www.gnu.org/software/gdb/bugs/>.
Find the GDB manual and other documentation resources online at:
  <http://www.gnu.org/software/gdb/documentation/>.

For help, type "help".
Type "apropos word" to search for commands related to "word"...
Reading symbols from ./calcul...
(gdb) list 12,15
12     printf("Число: ");
13     scanf("%f",&Numeral);
14     printf("Операция (+,-,*,/,pow,sqrt,sin,cos,tan): ");
15     scanf("%s",&Operation);
(gdb) list calculate.c:20,29
20     {
21     printf("Вычитаемое: ");
22     scanf("%f",&SecondNumeral);
23     return(Numeral - SecondNumeral);
24     }
25     else if(strncmp(Operation, "*", 1) == 0)
26     {
27     printf("Множитель: ");
28     scanf("%f",&SecondNumeral);
29     return(Numeral * SecondNumeral);
```

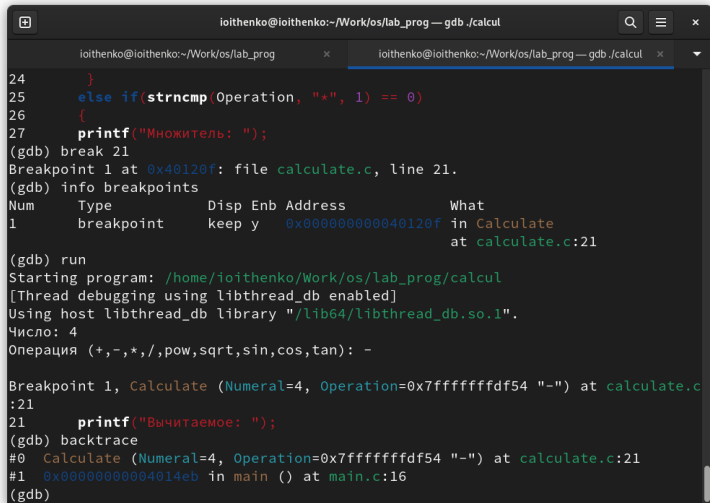
Выполнение лабораторной работы

Устанавливаю точку останова в файле calculate.c на строке номер 21 и вывожу информацию об имеющихся в проекте точках останова:



```
ioithenko@ioithenko:~/Work/os/lab_prog — gdb ./calcul
ioithenko@ioithenko:~/Work/os/lab_prog x ioithenko@ioithenko:~/Work/os/lab_prog — gdb ./calcul x
Using host libthread_db library "/lib64/libthread_db.so.1".
Число: 3
Операция (+,-,*,/,pow,sqrt,sin,cos,tan): +
Второе слагаемое: 2
5.00
[Inferior 1 (process 3328) exited normally]
Missing separate debuginfos, use: dnf debuginfo-install glibc-2.35-22.fc36.x86_64
(gdb) list calculate.c:20,27
20
21     printf("Вычитаемое: ");
22     scanf("%f",&SecondNumeral);
23     return(Numeral - SecondNumeral);
24 }
25 else if(strncmp(Operation, "*", 1) == 0)
26 {
27     printf("Множитель: ");
(gdb) break 21
Breakpoint 1 at 0x40120f: file calculate.c, line 21.
(gdb) info breakpoints
Num      Type             Disp Enb Address            What
1        breakpoint     keep y   0x000000000040120f in Calculate
at calculate.c:21
```

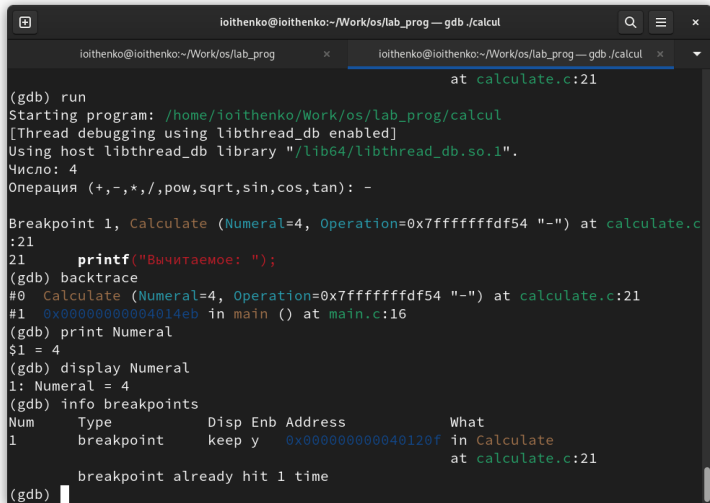
Выполнение лабораторной работы



```
ioithenko@ioithenko:~/Work/os/lab_prog — gdb ./calcul
ioithenko@ioithenko:~/Work/os/lab_prog x ioithenko@ioithenko:~/Work/os/lab_prog — gdb ./calcul x
24     }
25     else if(strncmp(Operation, "*", 1) == 0)
26     {
27         printf("Множитель: ");
(gdb) break 21
Breakpoint 1 at 0x40120f: file calculate.c, line 21.
(gdb) info breakpoints
Num      Type          Disp Enb Address              What
1        breakpoint    keep y   0x000000000040120f in Calculate
                                           at calculate.c:21
(gdb) run
Starting program: /home/ioithenko/Work/os/lab_prog/calcul
[Thread debugging using libthread_db enabled]
Using host libthread_db library "/lib64/libthread_db.so.1".
Число: 4
Операция (+,-,*,/,pow,sqrt,sin,cos,tan): -
Breakpoint 1, Calculate (Numeral=4, Operation=0x7fffffffdf54 "-") at calculate.c:21
21         printf("Вычитаемое: ");
(gdb) backtrace
#0 Calculate (Numeral=4, Operation=0x7fffffffdf54 "-") at calculate.c:21
#1 0x00000000004014eb in main () at main.c:16
(gdb)
```

Рис. 12: Проверка точки останова. просмотр стека вызываемых функций.

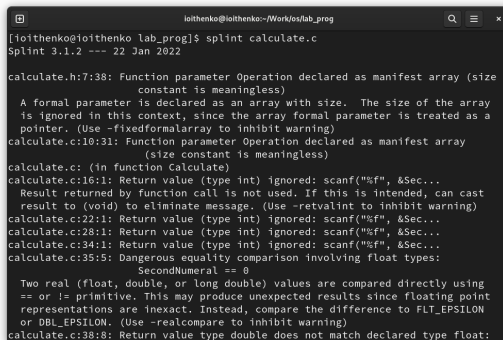
Выполнение лабораторной работы



```
ioithenko@ioithenko:~/Work/os/lab_prog — gdb ./calcul
ioithenko@ioithenko:~/Work/os/lab_prog x ioithenko@ioithenko:~/Work/os/lab_prog — gdb ./calcul x
at calculate.c:21
(gdb) run
Starting program: /home/ioithenko/Work/os/lab_prog/calcul
[Thread debugging using libthread_db enabled]
Using host libthread_db library "/lib64/libthread_db.so.1".
Число: 4
Операция (+,-,*,/,pow,sqrt,sin,cos,tan): -

Breakpoint 1, Calculate (Numeral=4, Operation=0x7fffffffdf54 "-") at calculate.c:21
21      printf("Вычитаемое: ");
(gdb) backtrace
#0 Calculate (Numeral=4, Operation=0x7fffffffdf54 "-") at calculate.c:21
#1 0x00000000004014eb in main () at main.c:16
(gdb) print Numeral
$1 = 4
(gdb) display Numeral
1: Numeral = 4
(gdb) info breakpoints
Num      Type             Disp Enb Address                  What
1        breakpoint       keep y  0x000000000040120f in Calculate
                                           at calculate.c:21
                                           breakpoint already hit 1 time
(gdb) 
```

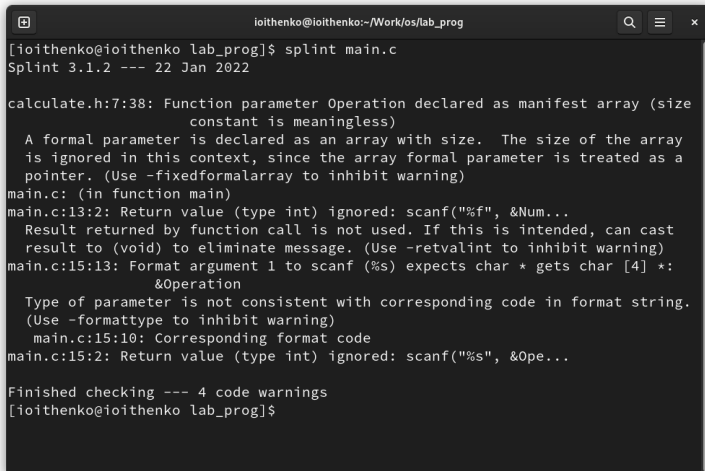
Рис. 13: Просмотр значения переменной Numeral и удаление точки останова.

A terminal window with a dark background and light text. The window title is 'ioithenko@ioithenko:~/Work/os/lab_prog'. The prompt is '[ioithenko@ioithenko lab_prog]\$' and the command entered is 'splint calculate.c'. The output shows several warnings from Splint 3.1.2, dated 22 Jan 2022. The warnings include: 1) A manifest array size constant is meaningless in calculate.h:7:38. 2) A formal parameter is declared as an array with size, which is ignored in this context in calculate.c:10:31. 3) Return values (type int) are ignored for scanf calls in calculate.c:16:1, calculate.c:22:1, calculate.c:28:1, and calculate.c:34:1. 4) A dangerous equality comparison involving float types in calculate.c:35:5. 5) A return value type mismatch (double vs float) in calculate.c:38:8.

```
ioithenko@ioithenko:~/Work/os/lab_prog
[ioithenko@ioithenko lab_prog]$ splint calculate.c
Splint 3.1.2 --- 22 Jan 2022

calculate.h:7:38: Function parameter Operation declared as manifest array (size
                    constant is meaningless)
    A formal parameter is declared as an array with size. The size of the array
    is ignored in this context, since the array formal parameter is treated as a
    pointer. (Use -fixedformalarray to inhibit warning)
calculate.c:10:31: Function parameter Operation declared as manifest array
                    (size constant is meaningless)
calculate.c: (in function Calculate)
calculate.c:16:1: Return value (type int) ignored: scanf("%f", &Sec...
    Result returned by function call is not used. If this is intended, can cast
    result to (void) to eliminate message. (Use -retvalint to inhibit warning)
calculate.c:22:1: Return value (type int) ignored: scanf("%f", &Sec...
calculate.c:28:1: Return value (type int) ignored: scanf("%f", &Sec...
calculate.c:34:1: Return value (type int) ignored: scanf("%f", &Sec...
calculate.c:35:5: Dangerous equality comparison involving float types:
                    SecondNumeral == 0
    Two real (float, double, or long double) values are compared directly using
    == or != primitive. This may produce unexpected results since floating point
    representations are inexact. Instead, compare the difference to FLT_EPSILON
    or DBL_EPSILON. (Use -realcompare to inhibit warning)
calculate.c:38:8: Return value type double does not match declared type float:
```

Рис. 14: Выполнение команды splint calculate.c.



```
ioithenko@ioithenko:~/Work/os/lab_prog
[ioithenko@ioithenko lab_prog]$ splint main.c
Splint 3.1.2 --- 22 Jan 2022

calculate.h:7:38: Function parameter Operation declared as manifest array (size
                    constant is meaningless)
    A formal parameter is declared as an array with size. The size of the array
    is ignored in this context, since the array formal parameter is treated as a
    pointer. (Use -fixedformalarray to inhibit warning)
main.c: (in function main)
main.c:13:2: Return value (type int) ignored: scanf("%f", &Num...
    Result returned by function call is not used. If this is intended, can cast
    result to (void) to eliminate message. (Use -retvalint to inhibit warning)
main.c:15:13: Format argument 1 to scanf ("%s") expects char * gets char [4] *:
                &Operation
    Type of parameter is not consistent with corresponding code in format string.
    (Use -formattype to inhibit warning)
    main.c:15:10: Corresponding format code
main.c:15:2: Return value (type int) ignored: scanf("%s", &ope...

Finished checking --- 4 code warnings
[ioithenko@ioithenko lab_prog]$
```

Рис. 15: Выполнение команды splint main.c.

В ходе выполнения лабораторной работы я приобрела простейшие навыки разработки, анализа, тестирования и отладки приложений в ОС типа UNIX/Linux на примере создания на языке программирования С калькулятора с простейшими функциями.