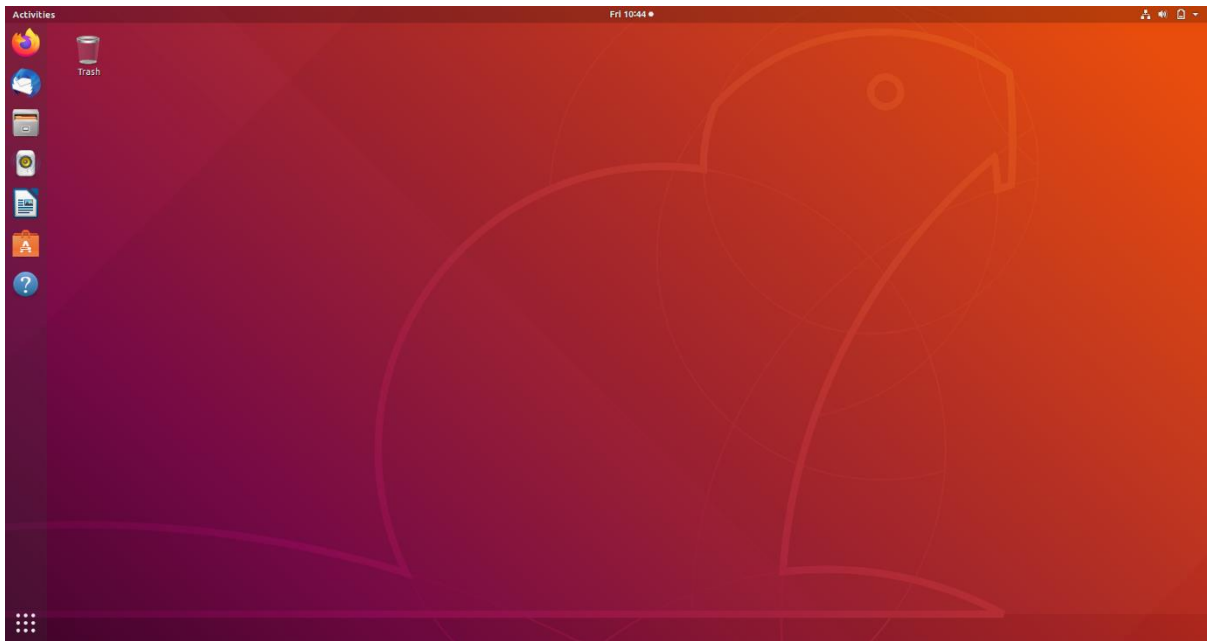
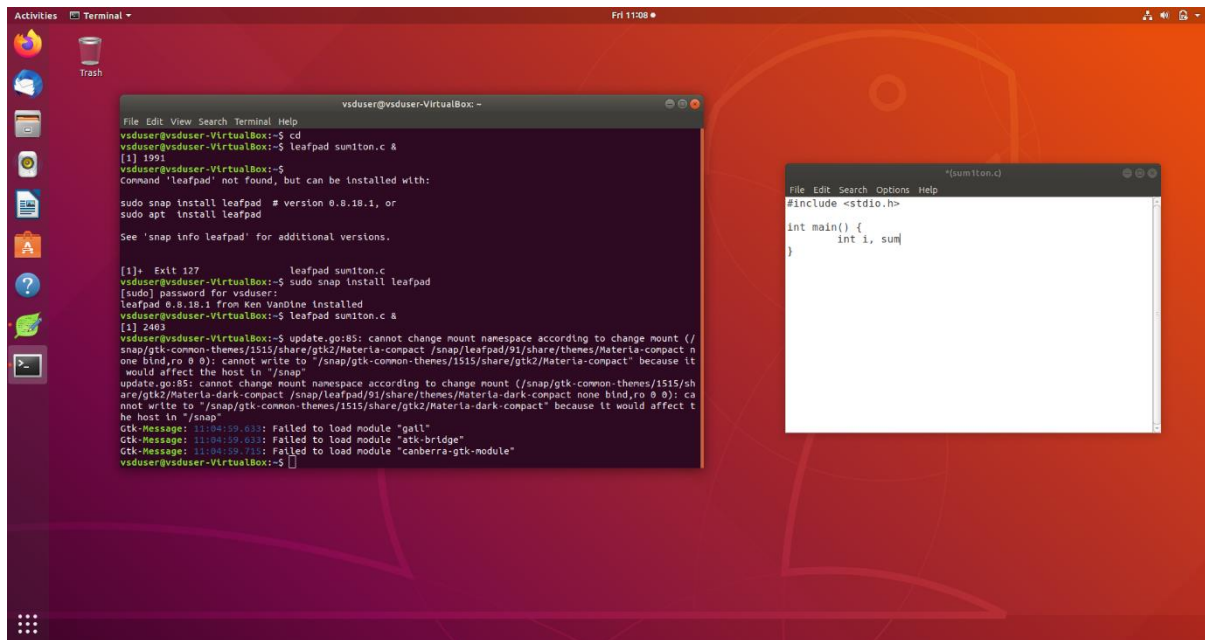


Writing a C code to count the sum of numbers from 1 to n and running this program using RISC-V simulator

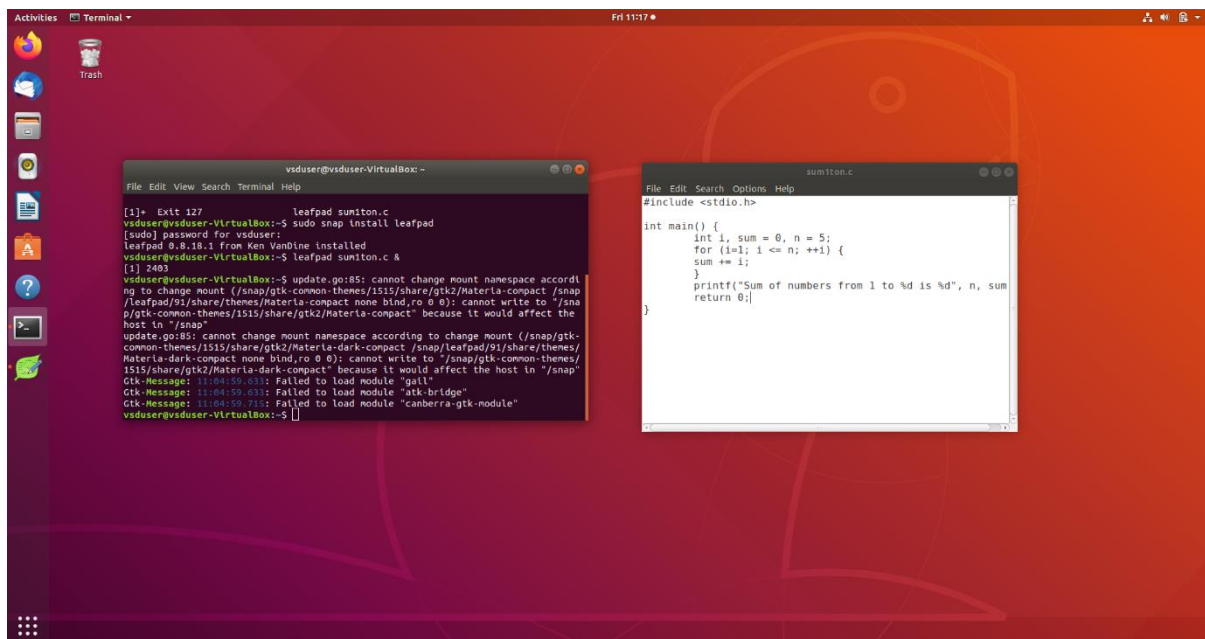
Writing a C code to count sum of numbers from 1 to n.



I . First, I opened the terminal and wrote code to create and open a new C file in Leaf pad, as demonstrated below:



II . Next, I wrote my code in Leaf pad as illustrated below :



III. Then I compiled and ran it in the terminal to verify, and achieved the desired output.

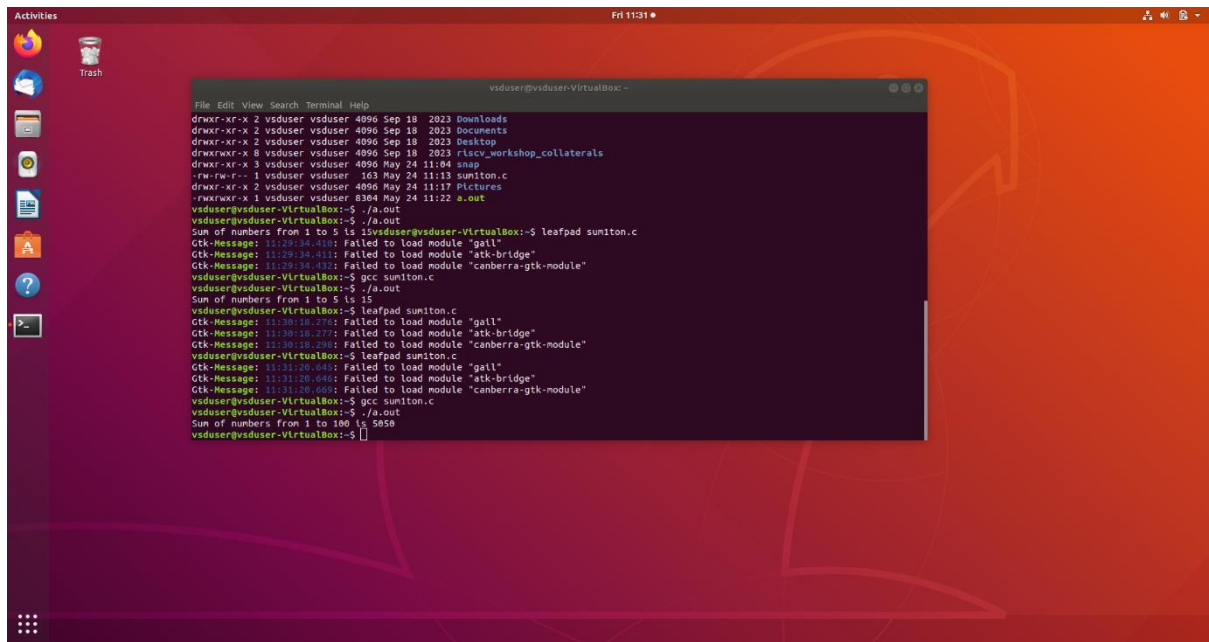
The screenshot shows a Linux desktop with a red background. A terminal window is open, displaying the output of a file listing command. The output shows a directory listing for the user 'vdsuser' in the 'vdsuser-VirtualBox' environment. The listing includes files like 'examples.desktop', 'Videos', 'Templates', 'Public', 'Music', 'Downloads', 'Documents', 'Desktop', 'riscv_workshop_collaterals', 'snap', 'suniton.c', 'Pictures', and 'a.out'. The terminal also shows the execution of a program and the output of a gcc compiler command. A code editor window is also open, showing the source code for 'suniton.c'.

```
File Edit View Search Terminal Help
[1]- Done leafpad suniton.c
vdsuser@vdsuser-VirtualBox:~$ ls -ltr
ls: cannot access '.': No such file or directory
ls: cannot access 'ltr': No such file or directory
vdsuser@vdsuser-VirtualBox:~$ ls -ltr
total 68
-rw-r--r-- 1 vdsuser vdsuser 8869 Sep 18 2023 examples.desktop
drwxr-xr-x 2 vdsuser vdsuser 4096 Sep 18 2023 Videos
drwxr-xr-x 2 vdsuser vdsuser 4096 Sep 18 2023 Templates
drwxr-xr-x 2 vdsuser vdsuser 4096 Sep 18 2023 Public
drwxr-xr-x 2 vdsuser vdsuser 4096 Sep 18 2023 Music
drwxr-xr-x 2 vdsuser vdsuser 4096 Sep 18 2023 Downloads
drwxr-xr-x 2 vdsuser vdsuser 4096 Sep 18 2023 Documents
drwxr-xr-x 2 vdsuser vdsuser 4096 Sep 18 2023 Desktop
drwxrwxr-x 8 vdsuser vdsuser 4096 Sep 18 2023 riscv_workshop_collaterals
drwxr-xr-x 3 vdsuser vdsuser 4096 May 24 11:04 snap
-rw-rw-r-- 1 vdsuser vdsuser 163 May 24 11:13 suniton.c
drwxr-xr-x 2 vdsuser vdsuser 4096 May 24 11:17 Pictures
-rwxrwxr-x 1 vdsuser vdsuser 8364 May 24 11:22 a.out
vdsuser@vdsuser-VirtualBox:~$ ./a.out
vdsuser@vdsuser-VirtualBox:~$ ./a.out
Sum of numbers from 1 to 5 is 15
vdsuser@vdsuser-VirtualBox:~$ leafpad suniton.c
Gtk-Message: 11:29:34.410: Failed to load module "gall"
Gtk-Message: 11:29:34.411: Failed to load module "atk-bridge"
Gtk-Message: 11:29:34.431: Failed to load module "canberra-gtk-module"
vdsuser@vdsuser-VirtualBox:~$ gcc suniton.c
vdsuser@vdsuser-VirtualBox:~$ ./a.out
Sum of numbers from 1 to 5 is 15
vdsuser@vdsuser-VirtualBox:~$
```

IV. Then I tested different values of n, such as n=100, and obtained the results.

The screenshot shows a Linux desktop with a red background. A terminal window is open, displaying the output of a file listing command. The output shows a directory listing for the user 'vdsuser' in the 'vdsuser-VirtualBox' environment. The listing includes files like 'Templates', 'Public', 'Music', 'Downloads', 'Documents', 'Desktop', 'riscv_workshop_collaterals', 'snap', 'suniton.c', 'Pictures', and 'a.out'. The terminal also shows the execution of a program and the output of a gcc compiler command. A code editor window is also open, showing the source code for 'suniton.c'.

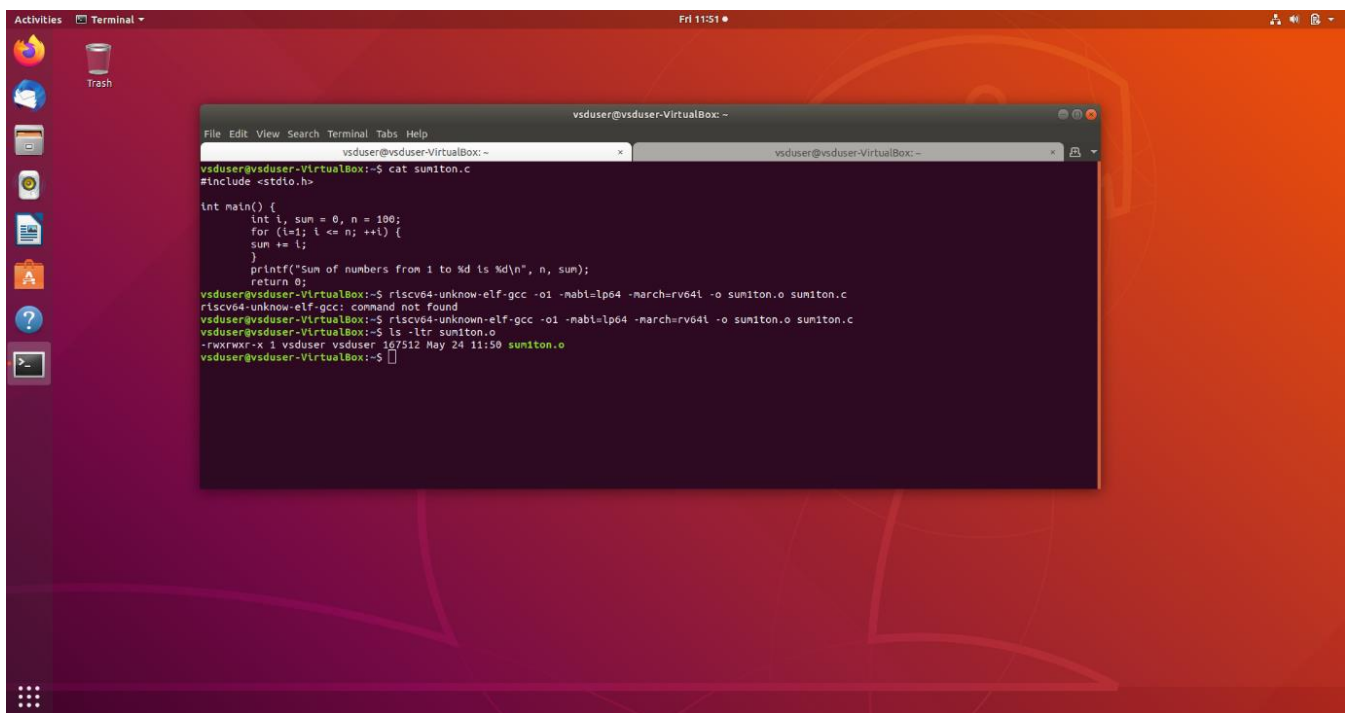
```
File Edit View Search Terminal Help
drwxr-xr-x 2 vdsuser vdsuser 4096 Sep 18 2023 Templates
drwxr-xr-x 2 vdsuser vdsuser 4096 Sep 18 2023 Public
drwxr-xr-x 2 vdsuser vdsuser 4096 Sep 18 2023 Music
drwxr-xr-x 2 vdsuser vdsuser 4096 Sep 18 2023 Downloads
drwxr-xr-x 2 vdsuser vdsuser 4096 Sep 18 2023 Documents
drwxr-xr-x 2 vdsuser vdsuser 4096 Sep 18 2023 Desktop
drwxrwxr-x 8 vdsuser vdsuser 4096 Sep 18 2023 riscv_workshop_collaterals
drwxr-xr-x 3 vdsuser vdsuser 4096 May 24 11:04 snap
-rw-rw-r-- 1 vdsuser vdsuser 163 May 24 11:13 suniton.c
drwxr-xr-x 2 vdsuser vdsuser 4096 May 24 11:17 Pictures
-rwxrwxr-x 1 vdsuser vdsuser 8364 May 24 11:22 a.out
vdsuser@vdsuser-VirtualBox:~$ ./a.out
vdsuser@vdsuser-VirtualBox:~$ ./a.out
Sum of numbers from 1 to 5 is 15
vdsuser@vdsuser-VirtualBox:~$ leafpad suniton.c
Gtk-Message: 11:29:34.410: Failed to load module "gall"
Gtk-Message: 11:29:34.411: Failed to load module "atk-bridge"
Gtk-Message: 11:29:34.431: Failed to load module "canberra-gtk-module"
vdsuser@vdsuser-VirtualBox:~$ gcc suniton.c
vdsuser@vdsuser-VirtualBox:~$ ./a.out
Sum of numbers from 1 to 5 is 15
vdsuser@vdsuser-VirtualBox:~$ leafpad suniton.c
Gtk-Message: 11:30:10.270: Failed to load module "gall"
Gtk-Message: 11:30:10.277: Failed to load module "atk-bridge"
Gtk-Message: 11:30:10.290: Failed to load module "canberra-gtk-module"
vdsuser@vdsuser-VirtualBox:~$ leafpad suniton.c
Gtk-Message: 11:31:26.045: Failed to load module "gall"
Gtk-Message: 11:31:26.046: Failed to load module "atk-bridge"
Gtk-Message: 11:31:26.046: Failed to load module "canberra-gtk-module"
vdsuser@vdsuser-VirtualBox:~$
```



Running above program in RISC-V Simulator

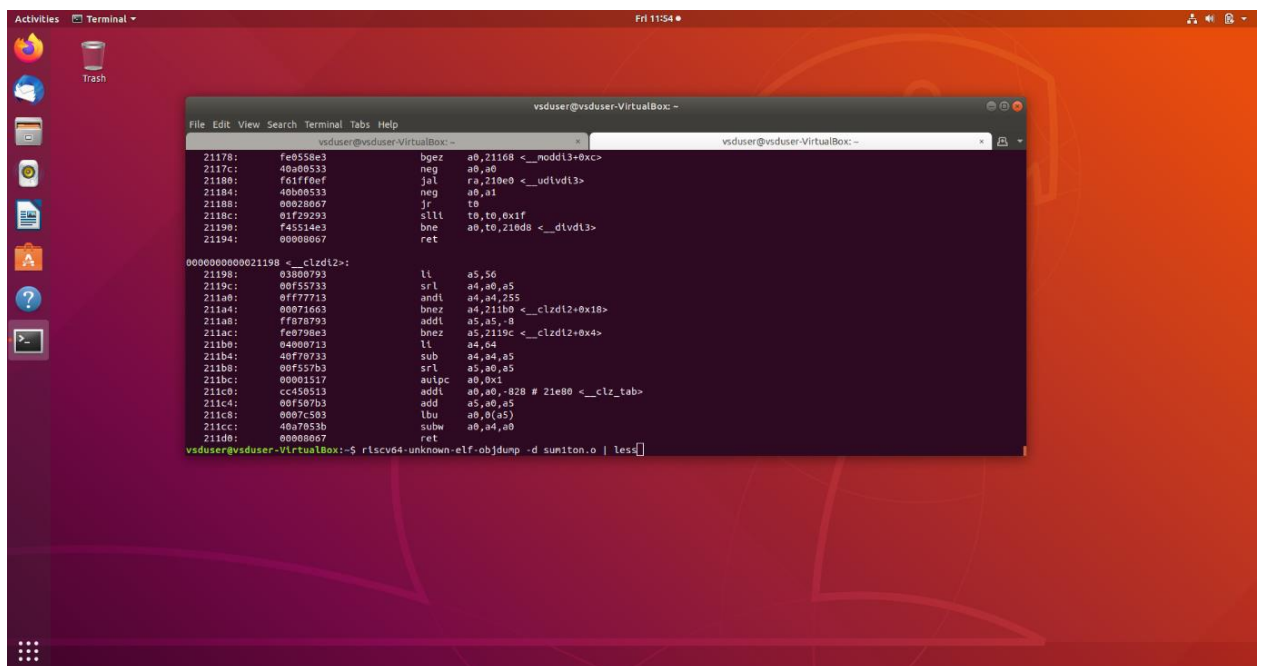
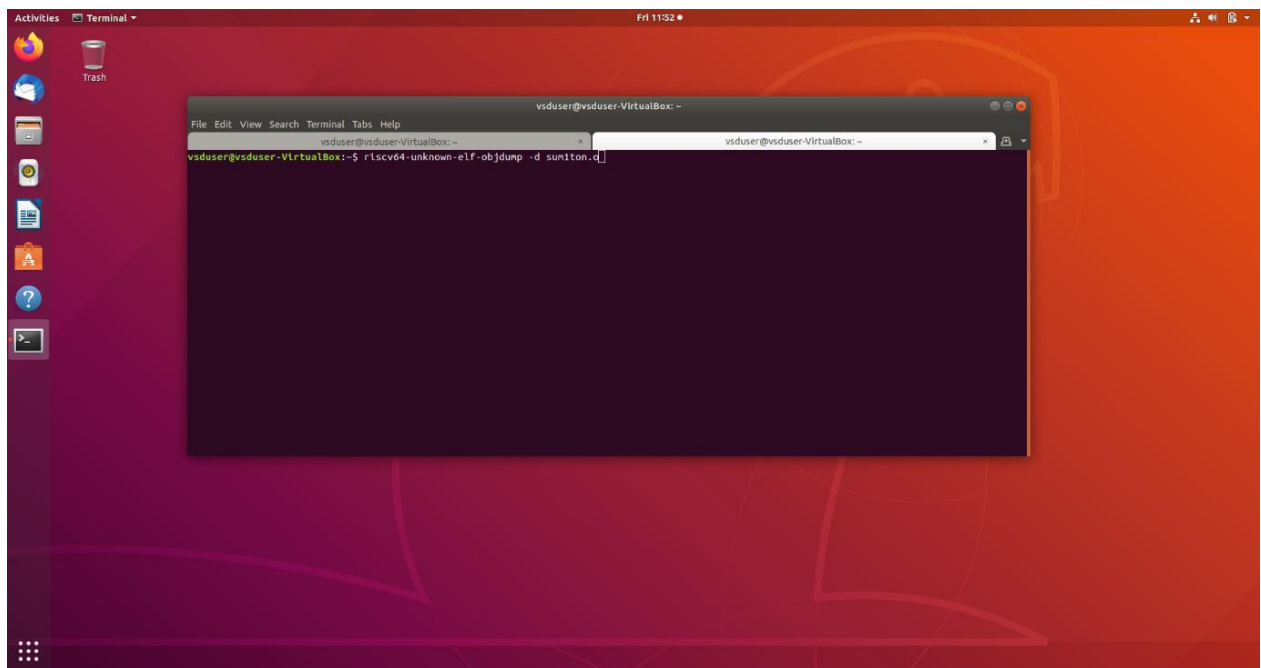
After running the code in the terminal, I need to execute it in the RISC-V simulator. For this, a specific set of code is required, which I have implemented in the following steps.:

- 1) First, I wrote code to compile it with the RISC-V GCC compiler using option 1, which generates a file with a .o extension.



```
vsduser@vsduser-VirtualBox:~  
vsduser@vsduser-VirtualBox:~$ cat suniton.c  
#include <stdio.h>  
  
int main() {  
    int i, sum = 0, n = 100;  
    for (i=1; i <= n; ++i) {  
        sum += i;  
    }  
    printf("Sum of numbers from 1 to %d is %d\n", n, sum);  
    return 0;  
}  
vsduser@vsduser-VirtualBox:~$ riscv64-unknown-elf-gcc -o1 -mabi=lp64 -march=rv64i -o suniton.o suniton.c  
riscv64-unknown-elf-gcc: command not found  
vsduser@vsduser-VirtualBox:~$ riscv64-unknown-elf-gcc -o1 -mabi=lp64 -march=rv64i -o suniton.o suniton.c  
vsduser@vsduser-VirtualBox:~$ ls -ltr suniton.o  
-rw-rw-r--x 1 vsduser vsduser 167512 May 24 11:50 suniton.o  
vsduser@vsduser-VirtualBox:~$
```

- 2) With the command `riscv-unknown-elf-objdump -d sun1ton.o` to obtain the assembly code for the above C program. This generated numerous assembly instructions, which I filtered by appending `| less` to the command. To locate the main section, I searched for "main." The byte address for main was found to be 10184, and there were 15 instructions when using option 1. It was observed that the address of each consecutive instruction increments by 4.



```

vtduser@vtduser-VirtualBox: ~
File Edit View Search Terminal Tabs Help
vtduser@vtduser-VirtualBox: ~
10178: 00000317 auipc t1,0x0
1017c: 00000067 jr zero # 0 <register_fint-0x100b0>
10180: 00000067 ret
0000000000010184 <exit>:
10184: fe011113 addi sp,sp,-32
10188: 00113c23 sd ra,24(sp)
1018c: 00113823 sd s0,10(sp)
10190: 02010413 addi s0,s0,32
10194: fe042423 sw zero, 24(s0)
10198: 0c400793 li a5,100
1019c: fef42223 sw a5,-28(s0)
10200: 0c000793 li a5,1
10204: fef42023 sw a5,-20(s0)
10208: 0200006f j 101c8 <exit+0x44>
1020c: fe042703 lw a4,-24(s0)
10210: fec42703 lw a5,-20(s0)
10214: 00f707bb addw a5,a4,a5
10218: fcf42423 sw a5,-24(s0)
1021c: fec42703 lw a5,-20(s0)
10220: 0017879b addiw a5,a5,1
10224: fef42623 sw a5,-20(s0)
10228: fec42703 lw a4,-28(s0)
1022c: fe042703 lw a5,-28(s0)
10230: 0007071b sext.w a4,a4
10234: 0007079b sext.w a5,a5
10238: fcf42403 bge a5,a4,101ac <exit+0x28>
1023c: fe042703 lw a4,-24(s0)
10240: fe042703 lw a5,-28(s0)
10244: 00070613 mv a2,a4
10248: 00078593 mv a1,a5
1024c: 000217b7 lui a5,0x21
10250: 1e078513 addi a0,a5,408 # 211e0 <__cld12+0x48>
10254: 274000ef jal ra,10460 <printf>
10258: 00000793 li a5,0
1025c: 00078513 mv a0,a5
10260: 01013003 ld ra,24(sp)
10264: 01013403 ld s0,10(sp)
10268: 02010113 addi sp,sp,32
1026c: 00000067 ret
0000000000010210 <exit>:
10210: 00050593 mv a1,a0
10214: 00000093 li a3,0
10218: 00000613 li a2,0
1021c: 00000513 li a0,0
10220: 4390200f j 10258 <__register_exitproc>
0000000000010224 <exit>:

```

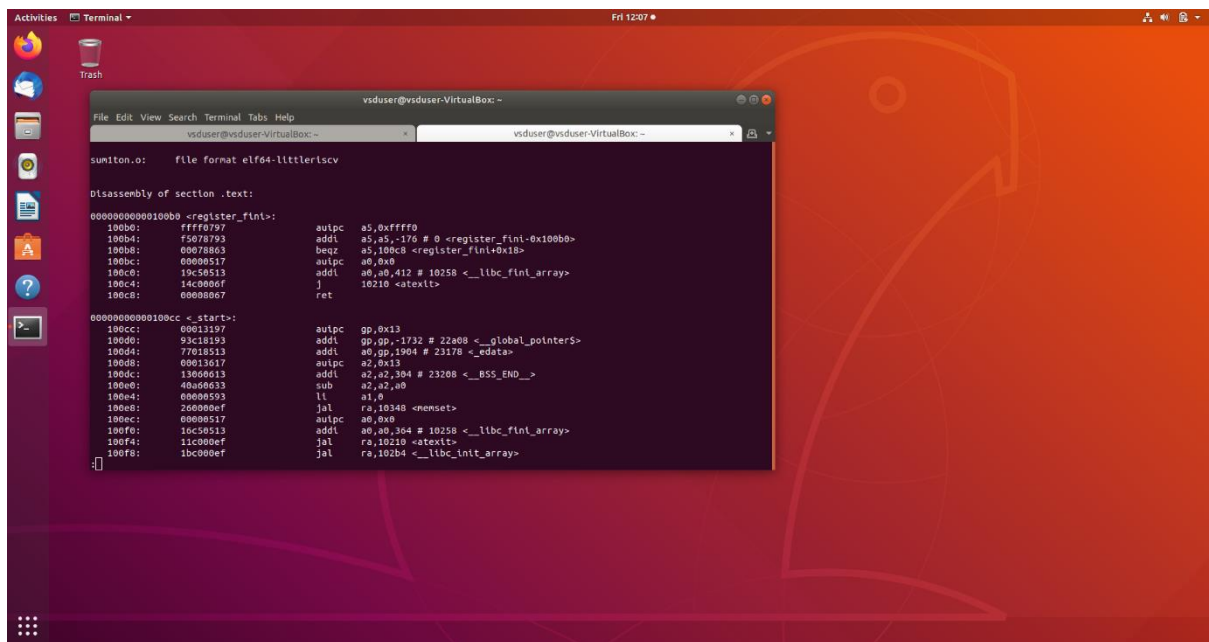
- Next, I ran the same commands but used the '-Ofast' option instead of '-O1'. This time, I got fewer instructions, specifically 12. This demonstrates that the assembly instructions in the file change based on the different compilation options used.

```

vtduser@vtduser-VirtualBox: ~
File Edit View Search Terminal Tabs Help
vtduser@vtduser-VirtualBox: ~
vtduser@vtduser-VirtualBox: ~
vtduser@vtduser-VirtualBox: ~$ cat sumiton.c
#include <stdio.h>

int main() {
    int i, sum = 0, n = 100;
    for (i=1; i <= n; ++i) {
        sum += i;
    }
    printf("Sum of numbers from 1 to %d is %d\n", n, sum);
    return 0;
}
vtduser@vtduser-VirtualBox: ~$ riscv64-unknown-elf-gcc -o1 -mabi=lp64 -march=rv64l -o sumiton.o sumiton.c
riscv64-unknown-elf-gcc: command not found
vtduser@vtduser-VirtualBox: ~$ riscv64-unknown-elf-gcc -o1 -mabi=lp64 -march=rv64l -o sumiton.o sumiton.c
vtduser@vtduser-VirtualBox: ~$ ls -l sumiton.o
-rwxr-xr-x 1 vtduser vtduser 4096 Oct 10 10:10 sumiton.o
vtduser@vtduser-VirtualBox: ~$ riscv64-unknown-elf-gcc -Ofast -mabi=lp64 -march=rv64l -o sumiton.o sumiton.c

```

The screenshot shows a Linux desktop with a red background and a large white outline of a person's head. A terminal window is open, displaying the output of a disassembly command. The terminal title is "vtduser@vtduser-VirtualBox: ~". The command entered is "sumiton.o: file format elf64-littlertscv". The output shows the disassembly of section ".text".

```
Disassembly of section .text:
0000000000100b0: <register_fini>:
100b0: fffff797          auipc a5,0xfffff0
100b4: 75678793          addi a5,a5,-176 # 0 <register_fini-0x100b0>
100b8: 00078863          beqz a5,100c8 <register_fini+0x18>
100bc: 00000517          auipc a6,0x0
100c0: 19c50513          addi a6,a6,412 # 10258 <__libc_fini_array>
100c4: 14c0000f          j 10210 <atexit>
100c8: 00000007          ret

0000000000100cc: <start>:
100cc: 00013197          auipc gp,0x13
100d0: 93c18193          addi gp,gp,-1732 # 22a08 <__global_pointer$>
100d4: 77618513          addi a6,gp,1904 # 23178 <edata>
100d8: 00013617          auipc a2,0x13
100dc: 13600013          addi a2,a2,304 # 23208 <_BSS_END__>
100e0: 40a00033          sub a2,a2,a0
100e4: 00000593          li a1,9
100e8: 200000ef          jal ra,10340 <memset>
100ec: 00000517          auipc a6,0x0
100f0: 19c50513          addi a6,a6,304 # 10258 <__libc_fini_array>
100f4: 11c000ef          jal ra,10210 <atexit>
100f8: 1bc000ef          jal ra,102b4 <__libc_init_array>
```

And that's all !!!