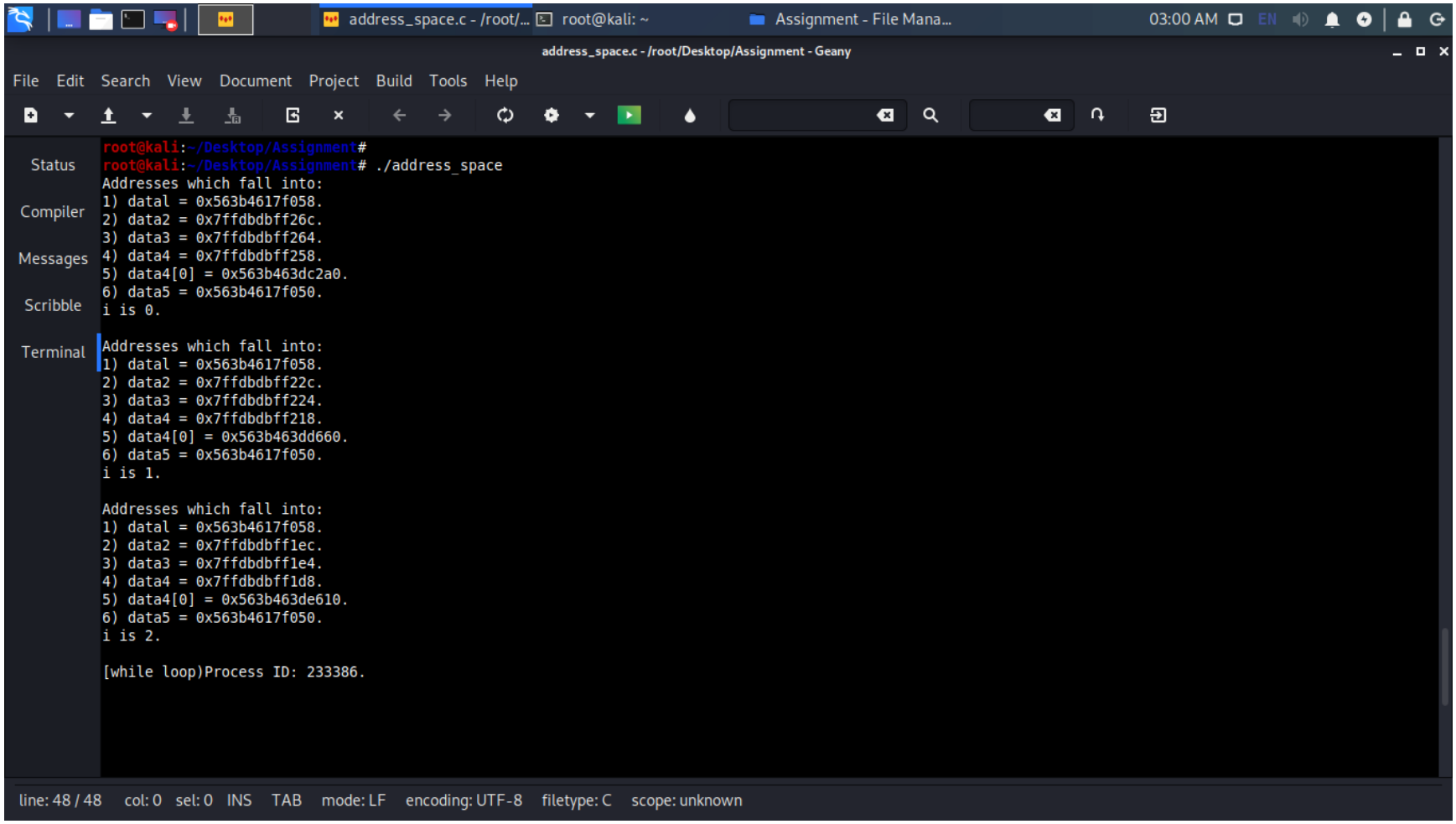
Exercise 2: Process Address Space

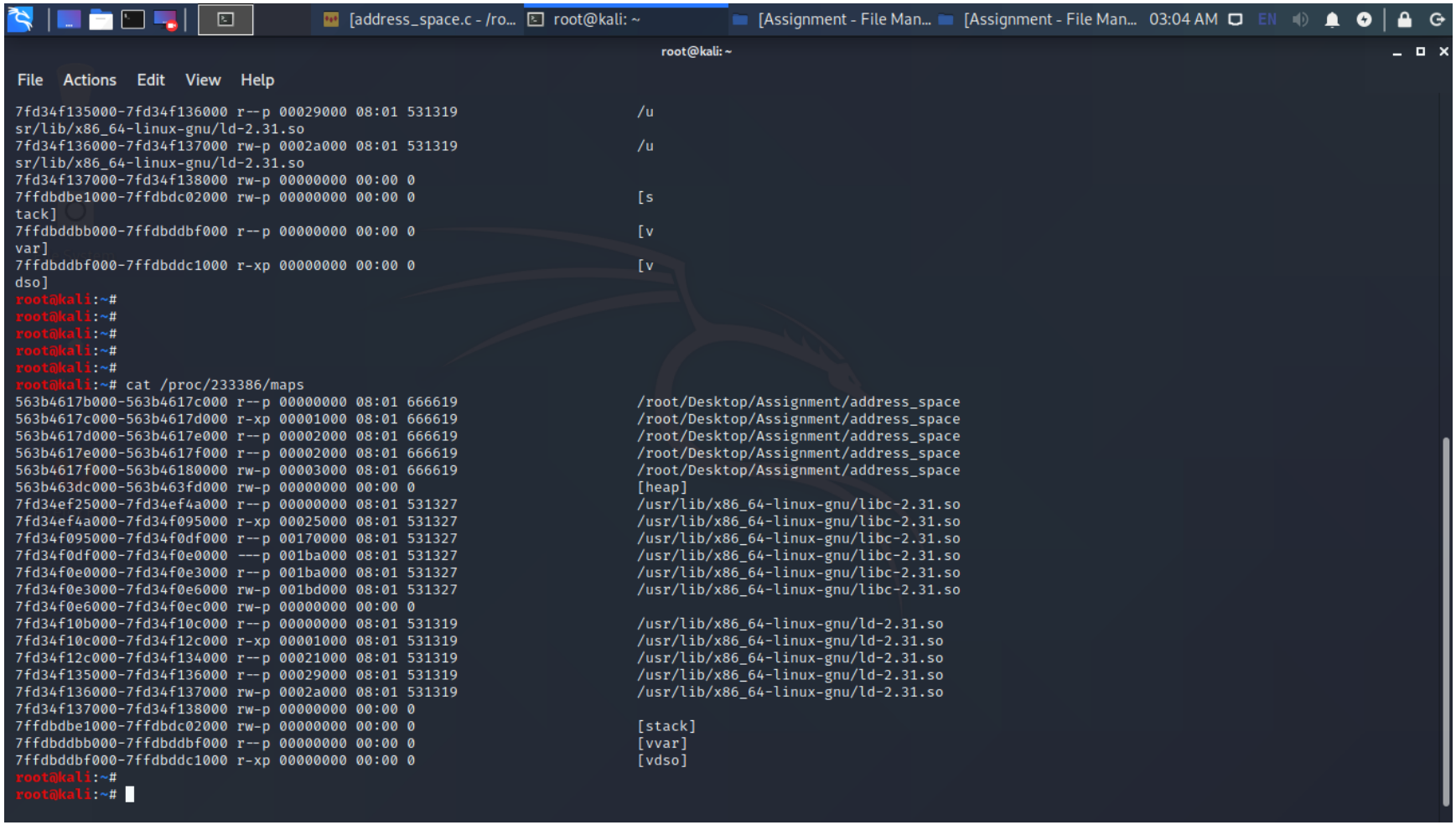
Code: exercise2.c

```
#include <stdio.h>
#include <stdlib.h>
#include <sys/types.h>
#include <unistd.h>

int data1;
void RecuresiveFunc1 (int i)
{
	data1= 1;
	int data2 = 1;
	int data3[2] = {1,1};
	int *data4 = malloc(1000*sizeof(int));
	data4[0] = data4[1] = 1;
	static int data5 =1;

	printf("Addresses which fall into:\n");
	printf("1) data1 = %p. \n", &data1);
	printf("2) data2 = %p. \n", &data2);
	printf("3) data3 = %p. \n", &data3);
	printf("4) data4 = %p. \n", &data4);
	printf("5) data4[0] = %p. \n", &data4[0]);
	printf("6) data5 = %p. \n", &data5);

	printf("i is %d.\n\n",i);
	if(i < 2)
	{
		RecuresiveFunc1 (++i) ;
	}
	else
	{
		while (1)
		{
			printf("[while loop)Process ID: %d.\n",getpid());
			sleep (100);
		}
		free(data4);
	}
}


int main (int argc, char *argv[])
{
	int i = 0;
	RecuresiveFunc1(i);
	return 0;
 }
```

Screenshot 1:



Screenshot 2:



Code Output

```
root@kali:~/Desktop/Assignment# ./address_space
Addresses which fall into:
1) datal = 0x563b4617f058.
2) data2 = 0x7ffdbdbff26c.
3) data3 = 0x7ffdbdbff264.
4) data4 = 0x7ffdbdbff258.
5) data4[0] = 0x563b463dc2a0.
6) data5 = 0x563b4617f050.
i is 0.

Addresses which fall into:
1) datal = 0x563b4617f058.
2) data2 = 0x7ffdbdbff22c.
3) data3 = 0x7ffdbdbff224.
4) data4 = 0x7ffdbdbff218.
5) data4[0] = 0x563b463dd660.
6) data5 = 0x563b4617f050.
i is 1.

Addresses which fall into:
1) datal = 0x563b4617f058.
2) data2 = 0x7ffdbdbff1ec.
3) data3 = 0x7ffdbdbff1e4.
4) data4 = 0x7ffdbdbff1d8.
5) data4[0] = 0x563b463de610.
6) data5 = 0x563b4617f050.
i is 2.

[while loop)Process ID: 233386.
```

Memory Map

```
root@kali:~# cat /proc/233386/maps
```

Sr. No.	Address	Permissions	Offset	Device	Inode	Pathname
1	563b4617b000-563b4617c000	r--p	00000000	08:01	666619	/root/Desktop/Assignment/address_space
2	563b4617c000-563b4617d000	r-xp	00001000	08:01	666619	/root/Desktop/Assignment/address_space
3	563b4617d000-563b4617e000	r--p	00002000	08:01	666619	/root/Desktop/Assignment/address_space
4	563b4617e000-563b4617f000	r--p	00002000	08:01	666619	/root/Desktop/Assignment/address_space
5	563b4617f000-563b46180000	rw-p	00003000	08:01	666619	/root/Desktop/Assignment/address_space
6	563b463dc000-563b463fd000	rw-p	00000000	00:00	0	[heap]
7	7fd34ef25000-7fd34ef4a000	r--p	00000000	08:01	531327	/usr/lib/x86_64-linux-gnu/libc-2.31.so
8	7fd34ef4a000-7fd34f095000	r-xp	00025000	08:01	531327	/usr/lib/x86_64-linux-gnu/libc-2.31.so
9	7fd34f095000-7fd34f0df000	r--p	00170000	08:01	531327	/usr/lib/x86_64-linux-gnu/libc-2.31.so
10	7fd34f0df000-7fd34f0e0000	---p	001ba000	08:01	531327	/usr/lib/x86_64-linux-gnu/libc-2.31.so
11	7fd34f0e0000-7fd34f0e3000	r--p	001ba000	08:01	531327	/usr/lib/x86_64-linux-gnu/libc-2.31.so
12	7fd34f0e3000-7fd34f0e6000	rw-p	001bd000	08:01	531327	/usr/lib/x86_64-linux-gnu/libc-2.31.so
13	7fd34f0e6000-7fd34f0ec000	rw-p	00000000	00:00	0	
14	7fd34f10b000-7fd34f10c000	r--p	00000000	08:01	531319	/usr/lib/x86_64-linux-gnu/ld-2.31.so
15	7fd34f10c000-7fd34f12c000	r-xp	00001000	08:01	531319	/usr/lib/x86_64-linux-gnu/ld-2.31.so
16	7fd34f12c000-7fd34f134000	r--p	00021000	08:01	531319	/usr/lib/x86_64-linux-gnu/ld-2.31.so
17	7fd34f135000-7fd34f136000	r--p	00029000	08:01	531319	/usr/lib/x86_64-linux-gnu/ld-2.31.so
18	7fd34f136000-7fd34f137000	rw-p	0002a000	08:01	531319	/usr/lib/x86_64-linux-gnu/ld-2.31.so
19	7fd34f137000-7fd34f138000	rw-p	00000000	00:00	0	
20	7ffdbdbe1000-7ffdbdc02000	rw-p	00000000	00:00	0	[stack]
21	7ffdbddbb000-7ffdbddbf000	r--p	00000000	00:00	0	[vvar]
22	7ffdbddbf000-7ffdbddc1000	r-xp	00000000	00:00	0	[vdso]

Solution

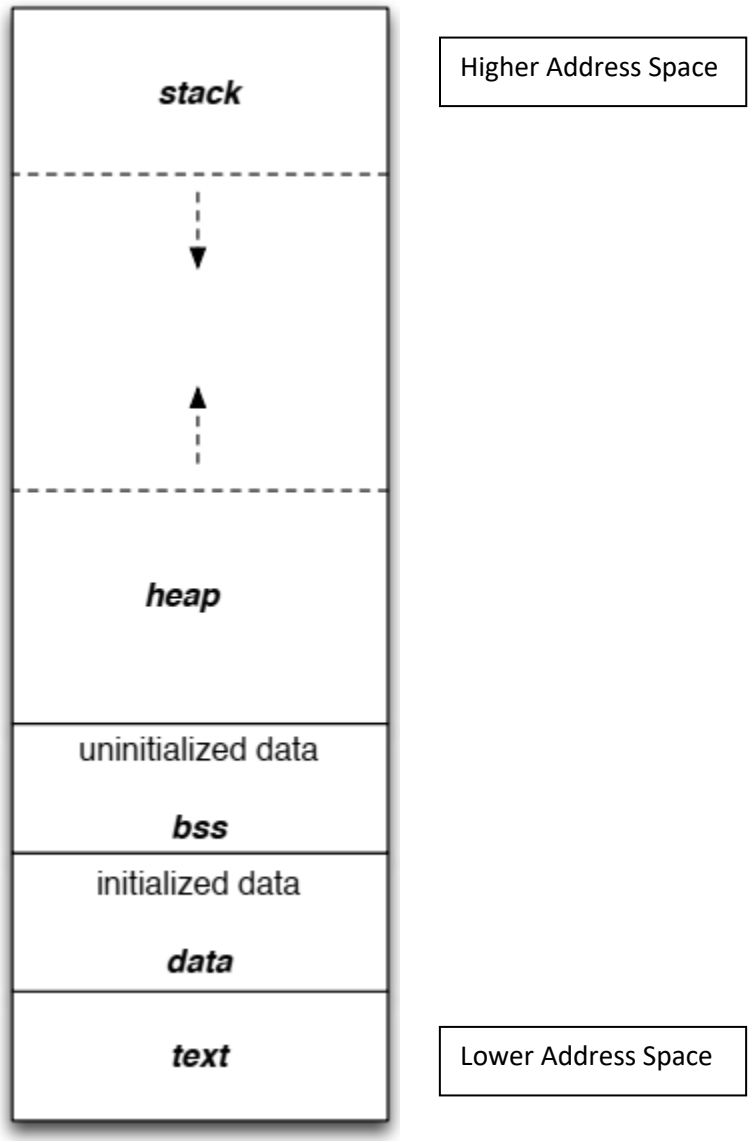
For the variables *data1, data2, data3, data4, data4[0], data5*:

(1) Where are these variables stored? Give you reasons.

A. Code segment
B. Data segment
C. BSS
D. Heap
E. Stack segment

Answer:

Following diagram shows typical layout of a simple computer's program memory with the text, various data, and stack and heap sections.



- data1 memory address is 0x563b4617f058 in all three recursive calls. This address lies in address range [563b4617f000-563b46180000] (Serial No. 5) which is **BSS** because BSS section is immediately before Heap section (Serial No. 6).
- data2 memory address are 0x7ffdbdbff26c, 0x7ffdbdbff22c, and 0x7ffdbdbff1ec in three recursive function calls. All of these address lie in **Stack section** [7ffdbdbe1000-7ffdbdc02000] (Serial No. 20). Because this is a local variable.
- data3 memory address are 0x7ffdbdbff264, 0x7ffdbdbff224, and 0x7ffdbdbff1e4 respectively for three recursive function calls. All of these address lie in **Stack section** [7ffdbdbe1000-7ffdbdc02000] (Serial No. 20). Because this is a local variable.
- data4 memory address are 0x7ffdbdbff258, 0x7ffdbdbff218, and 0x7ffdbdbff1d8 respectively for three recursive function calls. All of these address lie in **Stack section** [7ffdbdbe1000-7ffdbdc02000] (Serial No. 20). Because this is a point type variable and is a local variable.
- data4[0] memory address are 0x563b463dc2a0, 0x563b463dd660, and 0x563b463de610 respectively for three recursive function calls. All of these address lie in **Heap section** [563b463dc000-563b463fd000] (Serial No. 6). Because this is dynamically allocated space used by all three recursive function calls.
- data5 memory address are 0x563b4617f050, 0x563b4617f050, and 0x563b4617f050 respectively for three recursive function calls. All of these address lie in **BSS** [563b4617f000-563b46180000] (Serial No. 5). Because this is static variable.

(2) Estimate the stack size of RecursiveFunc1 and give your reasons.

Stack Frame on First Function Call

Locals of RecursiveFunc1
Return Address to Main Function
Parameters for RecursiveFunc1
Locals of Main Function
Return Address to OS
Parameters for Main Function
……..
……..

Because 1 parameter of type integer is passed to **RecursiveFunc1** function and data2, data3, *data4 are local variables. So estimated size of stack for **RecursiveFunc1** is

Parameter (4 bytes)+ return address (4 bytes) + 3 local variables (12 bytes) = 20 bytes

For three recursive calls 20 bytes * 3 = 60 bytes.