

## Operating System HW1 Programming exercises

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Class: 資工三

### Programming Problems : 2.15, 3.14

Folder name description:

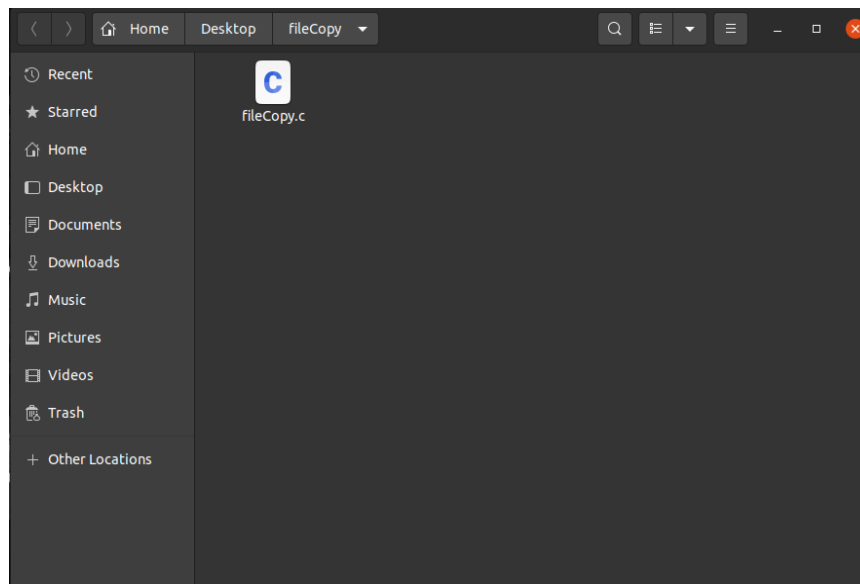
- **fileCopy** → Programming Problems Chap.2, Question number 2.15
- **collatzConjecture** → Programming Problems Chap. 3, Question number 3.14

### Programming Problems

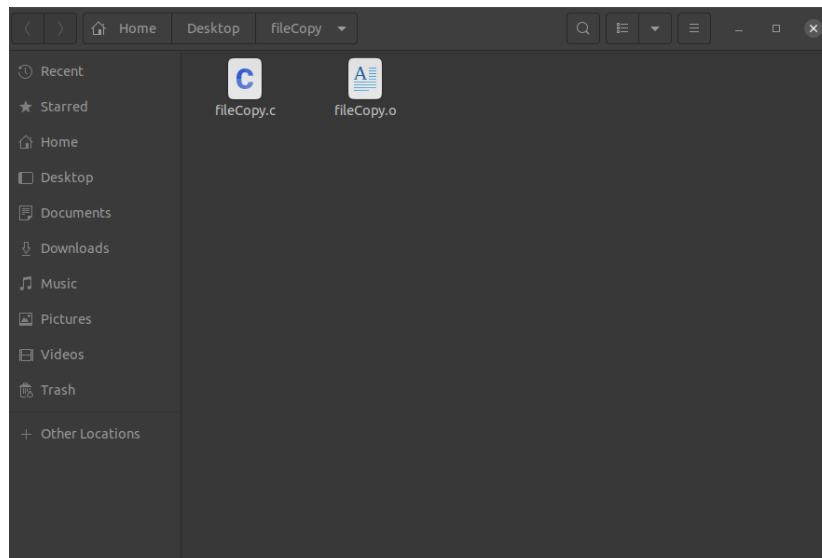
#### Chap. 2

#### Question number 2.15

Using Linux, go to the folder name fileCopy then open the linux terminal inside of the folder,

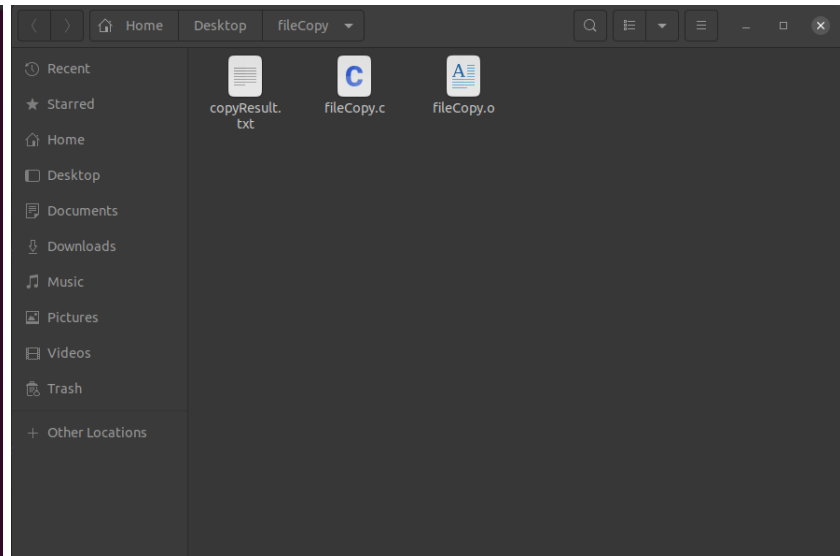


then in the linux terminal, input **gcc fileCopy.c -o fileCopy.o**

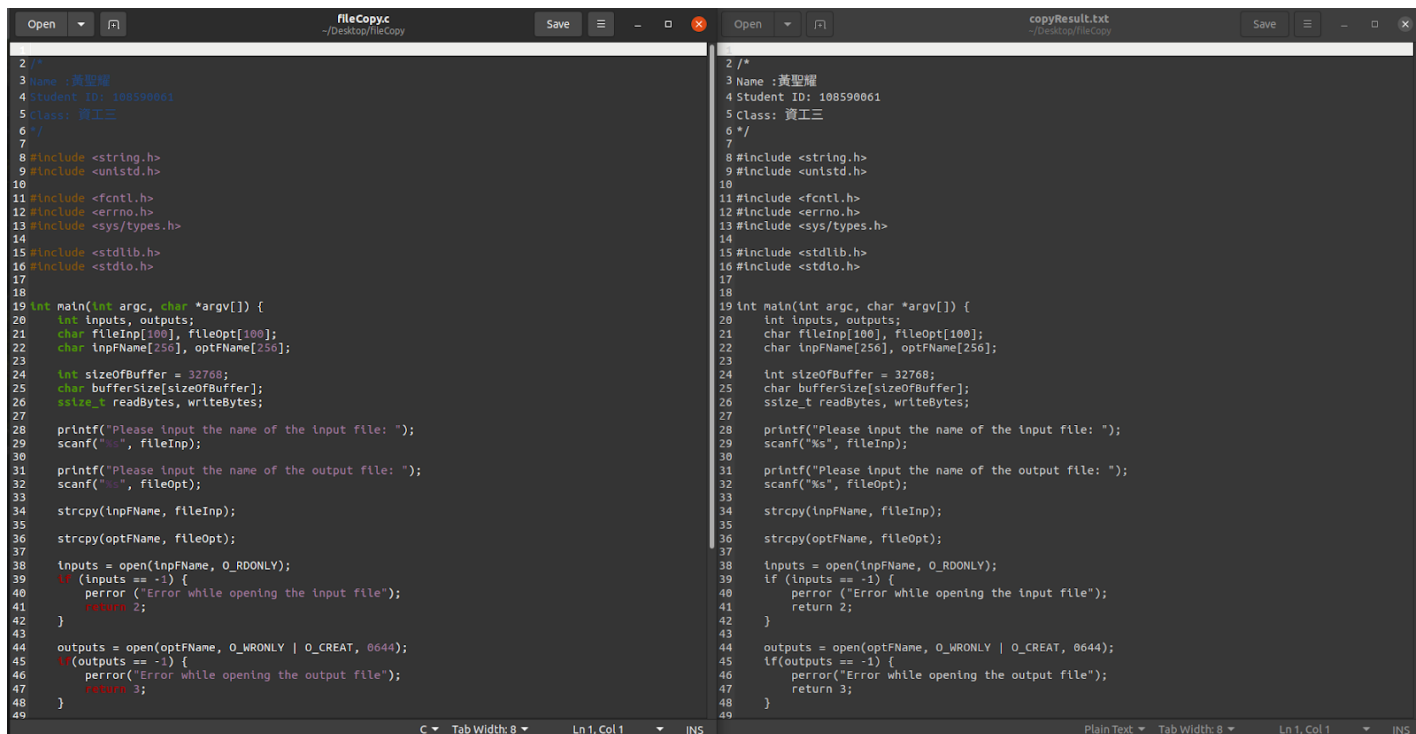


Then input **./fileCopy.o**, input the name of the file that wanted to be copied and the output file (example: copyResult.txt) as shown below, then the result will show that the file is successfully copied and the output file shown in the folder.

```
star@ubuntu:~/Desktop/fileCopy$ gcc fileCopy.c -o fileCopy.o
star@ubuntu:~/Desktop/fileCopy$ ./fileCopy.o
Please input the name of the input file: fileCopy.c
Please input the name of the output file: copyResult.txt
The file is successfully copied
star@ubuntu:~/Desktop/fileCopy$
```



The example of the result:



As shown above, the file is copied successfully.

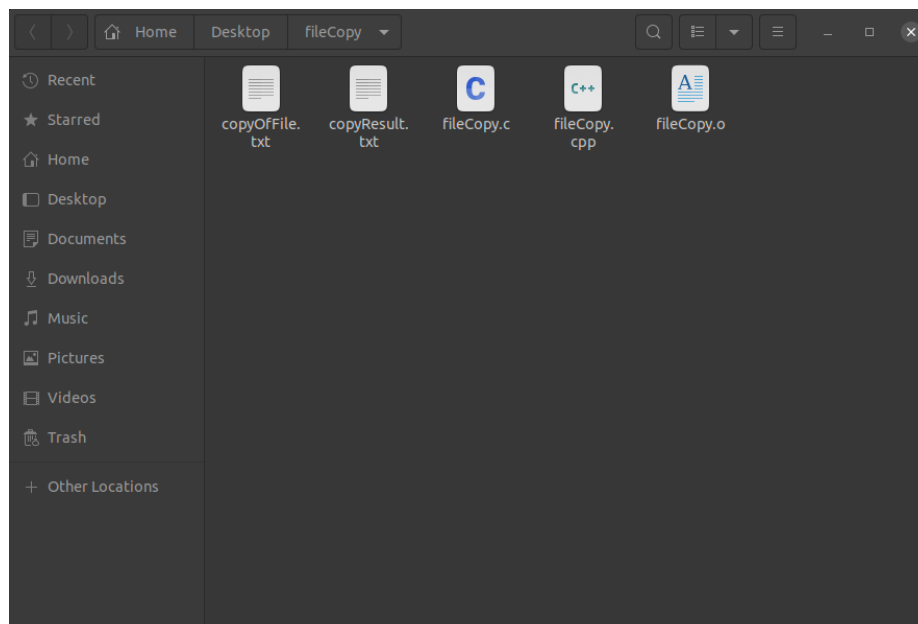
Error checking such as if the input file didn't exist,

```
star@ubuntu:~/Desktop/fileCopy$ gcc fileCopy.c -o fileCopy.o
star@ubuntu:~/Desktop/fileCopy$ ./fileCopy.o
Please input the name of the input file: myFiles.c
Please input the name of the output file: theResults.txt
Error while opening the input file: No such file or directory
star@ubuntu:~/Desktop/fileCopy$
```

Also, to copy again or copy to another format, input the **./fileCopy.o** again in the Linux terminal, for example:

```
star@ubuntu:~/Desktop/fileCopy$ gcc fileCopy.c -o fileCopy.o
star@ubuntu:~/Desktop/fileCopy$ ./fileCopy.o
Please input the name of the input file: fileCopy.c
Please input the name of the output file: copyResult.txt
The file is successfully copied
star@ubuntu:~/Desktop/fileCopy$ ./fileCopy.o
Please input the name of the input file: fileCopy.c
Please input the name of the output file: copyOfFile.txt
The file is successfully copied
star@ubuntu:~/Desktop/fileCopy$ ./fileCopy.o
Please input the name of the input file: fileCopy.c
Please input the name of the output file: fileCopy.cpp
The file is successfully copied
star@ubuntu:~/Desktop/fileCopy$
```

Therefore, the result as shown in the folder, now the folder has several files that has been copied successfully with different names or formats:



Using **strace** utility provided by the Linux systems, the results:

```

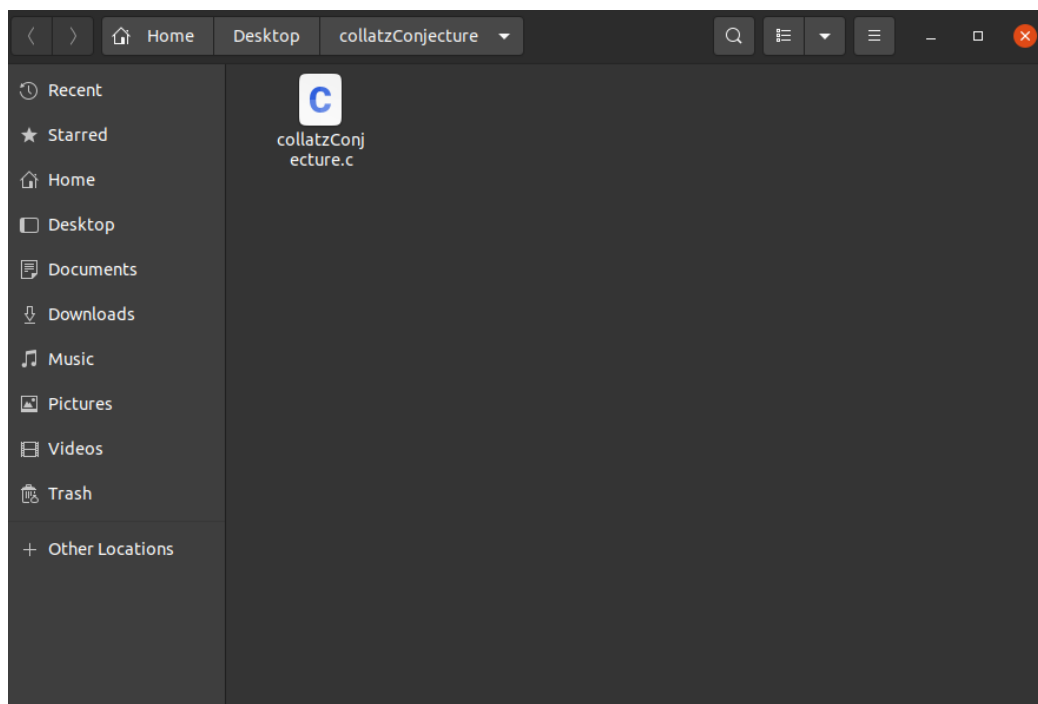
str@ubuntu:~/Desktop/fileCopy$ strace ./fileCopy.o
execve("./fileCopy.o", [".fileCopy.o"], 0x7ffdd5a291d0 /* ^8 vars */) = 0
brk(NULL)                                = 0x5622e4ef9000
arch_prctl(0x3001 /* ARCH_??? */, 0x7fff3ee820f0) = -1 EINVAL (Invalid argument)
access("/etc/ld.so.preload", R_OK)       = -1 ENOENT (No such file or directory)
openat(AT_FDCWD, "/etc/ld.so.cache", O_RDONLY|O_CLOEXEC) = 3
fstat(3, {st_mode=S_IFREG|0644, st_size=68086, ...}) = 0
mmap(NULL, 68086, PROT_READ, MAP_PRIVATE, 3, 0) = 0x7f461eae0000
close(3)                                 = 0
openat(AT_FDCWD, "/lib/x86_64-linux-gnu/libc.so.6", O_RDONLY|O_CLOEXEC) = 3
read(3, "\177ELF\2\1\1\3\0\0\0\0\0\0\0\0\0\0\0\0>\0\1\0\0\0\0360A\2\0\0\0\0\0"... , 832) = 832
pread64(3, "\6\0\0\0\4\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0...", 784, 64) = 784
pread64(3, "\4\0\0\0\20\0\0\0\0\5\0\0\0\0GGNU\0\2\0\0\300\4\0\0\0\3\0\0\0\0\0\0", 32, 848) = 32
pread64(3, "\4\0\0\0\24\0\0\0\0\3\0\0\0\0GNU\0\237\333t\347\262\27\320l\223\27*\202C\370T\177"... , 68, 880) = 68
fstat(3, {st_mode=S_IFREG|0755, st_size=2029560, ...}) = 0
mmap(NULL, 8192, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_ANONYMOUS, -1, 0) = 0x7f461eaea000
pread64(3, "\6\0\0\0\4\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0\0...", 784, 64) = 784
pread64(3, "\4\0\0\0\20\0\0\0\0\5\0\0\0\0GGNU\0\2\0\0\300\4\0\0\0\3\0\0\0\0\0\0", 32, 848) = 32
pread64(3, "\4\0\0\0\24\0\0\0\0\3\0\0\0\0GNU\0\237\333t\347\262\27\320l\223\27*\202C\370T\177"... , 68, 880) = 68
mmap(NULL, 2037344, PROT_READ, MAP_PRIVATE|MAP_DENYWRITE, 3, 0) = 0x7f461e8f0000
mmap(0x7f461e91a000, 1540096, PROT_READ|PROT_EXEC, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x22000) = 0x7f461e91a000
mmap(0x7f461ea92000, 319488, PROT_READ, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x19a000) = 0x7f461ea92000
mmap(0x7f461eae0000, 24576, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_DENYWRITE, 3, 0x1e7000) = 0x7f461eae0000
mmap(0x7f461eae6000, 13920, PROT_READ|PROT_WRITE, MAP_PRIVATE|MAP_FIXED|MAP_ANONYMOUS, -1, 0) = 0x7f461eae6000
close(3)                                 = 0
arch_prctl(ARCH_SET_FS, 0x7f461eae540) = 0
mprotect(0x7f461eae0000, 16384, PROT_READ) = 0
mprotect(0x5622e436c000, 4096, PROT_READ) = 0
mprotect(0x7f461eb2a000, 4096, PROT_READ) = 0
munmap(0x7f461eae0000, 68086)            = 0
fstat(1, {st_mode=S_IFCHR|0620, st_rdev=makedev(0x88, 0), ...}) = 0
brk(NULL)                                = 0x5622e4ef9000
brk(0x5622e4f1a000)                      = 0x5622e4f1a000
fstat(0, {st_mode=S_IFCHR|0620, st_rdev=makedev(0x88, 0), ...}) = 0
write(1, "Please input the name of the inp"... , 41)Please input the name of the input file: ) = 41
read(0, 0x5622e4ef96b0, 1024)           = ? ERESTARTSYS (To be restarted if SA_RESTART is set)
--- SIGWINCH({si_signo=SIGWINCH, si_code=SI_KERNEL} ---
read(0, 0x5622e4ef96b0, 1024)           = ? ERESTARTSYS (To be restarted if SA_RESTART is set)

```

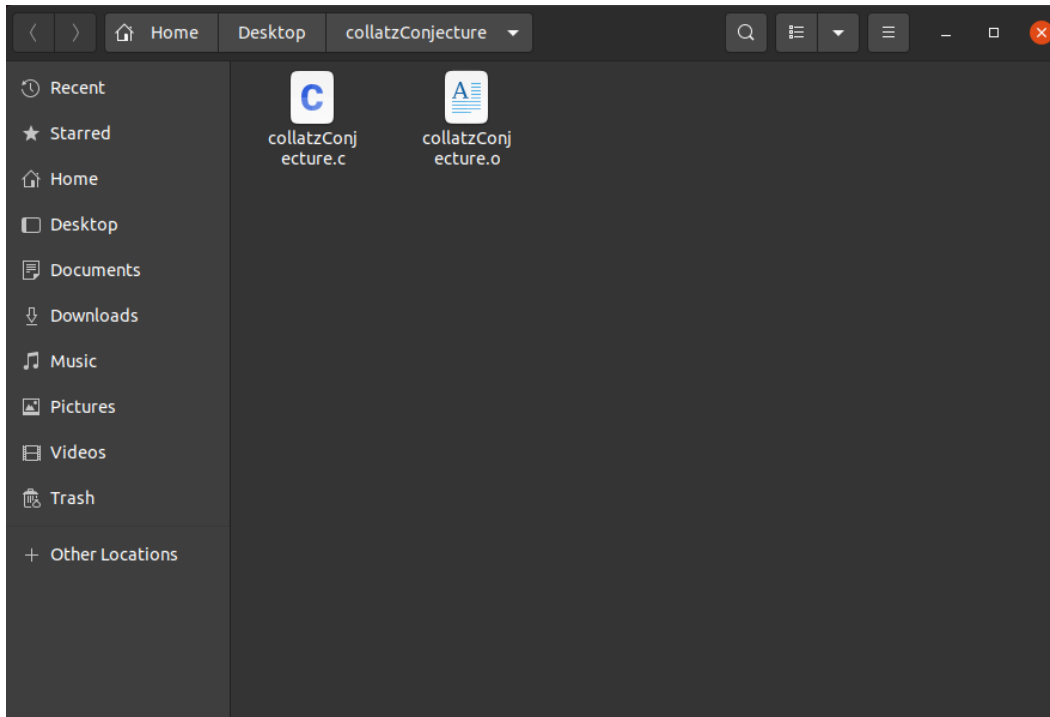
## Chap. 3

### Question number 3.14

Using Linux, go to the folder name collatzConjecture then open the linux terminal inside of the folder,



then in the linux terminal, input **gcc -g collatzConjecture.c -o collatzConjecture.o**



Then input **./collatzConjecture.o** with an argument in which the argument is a positive integer for example, **./collatzConjecture.o 35** and then it will output the result or as shown below:

```
star@ubuntu:~/Desktop/collatzConjecture$ gcc -g collatzConjecture.c -o collatzConjecture.o
star@ubuntu:~/Desktop/collatzConjecture$ ./collatzConjecture.o 35
35, 106, 53, 160, 80, 40, 20, 10, 5, 16, 8, 4, 2, 1
star@ubuntu:~/Desktop/collatzConjecture$
```

Another example:

```
star@ubuntu:~/Desktop/collatzConjecture$ ./collatzConjecture.o 8
8, 4, 2, 1
star@ubuntu:~/Desktop/collatzConjecture$
```

Error checking to ensure that a positive integer is passed on the command line:

```
star@ubuntu:~/Desktop/collatzConjecture$ ./collatzConjecture.o -5
Please input positive integer
star@ubuntu:~/Desktop/collatzConjecture$ ./collatzConjecture.o -1
Please input positive integer
star@ubuntu:~/Desktop/collatzConjecture$ ./collatzConjecture.o -100
Please input positive integer
star@ubuntu:~/Desktop/collatzConjecture$
```

# Operating Systems Programming Projects for Chap.2 & Chap. 3

## Team members:

資工三 方文昊 108590048 (Wrote and designed the programs and documentation)

資工三 鄭琳玲 108590056 (Wrote and designed the programs and documentation)

資工三 黃聖耀 108590061 (Wrote and designed the programs and documentation)

電資三 李以謙 108820021 (Wrote and designed the programs and documentation)

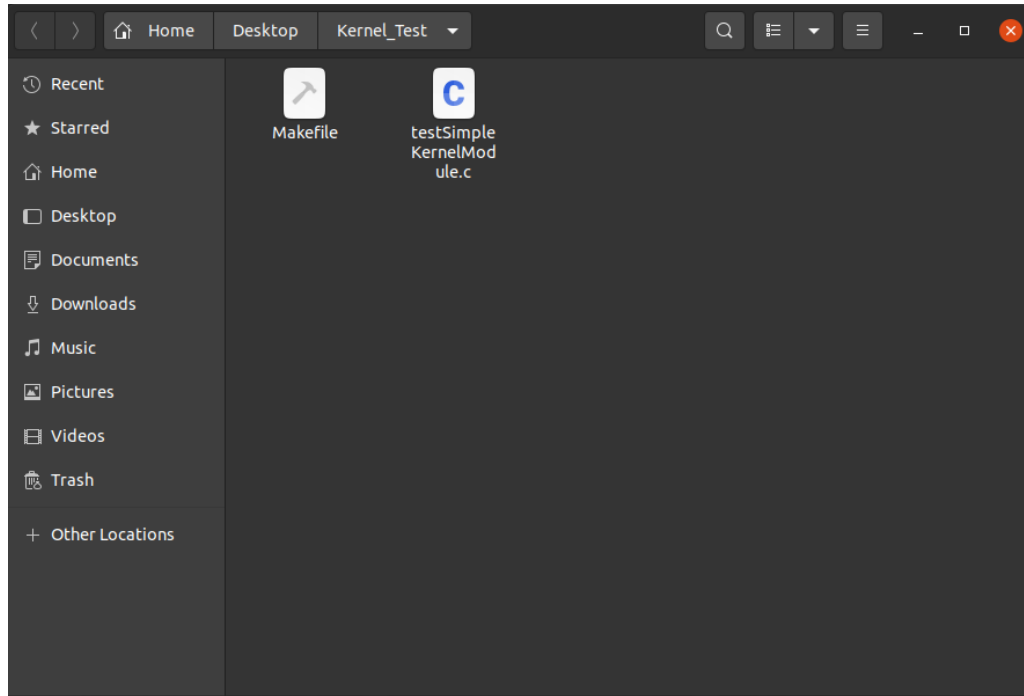
## Folder name description:

- **testSimpleKernelModule** → Programming Projects Chap. 2, Part I
- **chap2\_2** → Programming Projects Chap. 2, Part II
- **unixShell** → Programming Projects Chap. 3, Project 1, Part I & Part II
- **linearlyListTasks** → Programming Projects Chap. 3, Project 2, Part I
- **dfsTree** → Programming Projects Chap. 3, Project 2, Part II

## Programming Project for Chap. 2

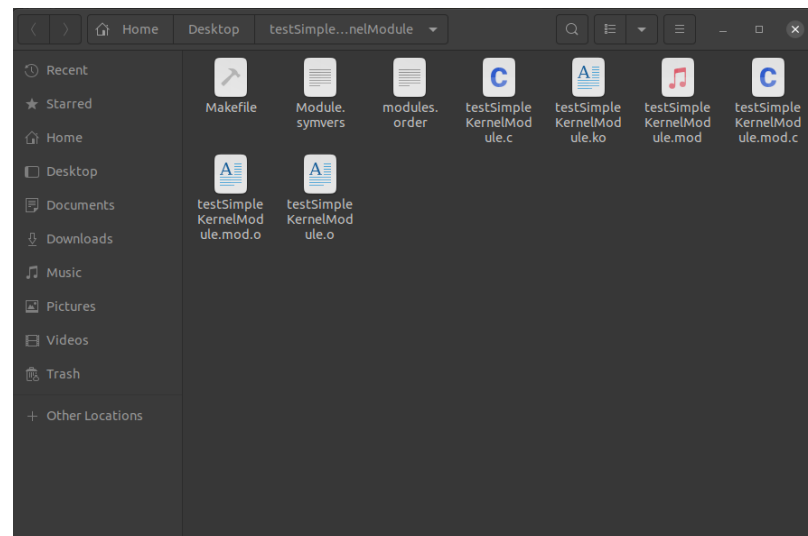
### Part I

In Linux, go to the testSimpleKernelModule folder, then open the linux terminal inside of the folder,



Then input **make** in the terminal, where it will produce several files,

```
star@ubuntu:~/Desktop/testSimpleKernelModule$ make
make -C /usr/src/linux-headers-5.13.0-35-generic M=/home/star/Desktop/testSimpleKernelModule modules
make[1]: Entering directory '/usr/src/linux-headers-5.13.0-35-generic'
  CC [M] /home/star/Desktop/testSimpleKernelModule/testSimpleKernelModule.o
  MODPOST /home/star/Desktop/testSimpleKernelModule/Module.symvers
  CC [M] /home/star/Desktop/testSimpleKernelModule/testSimpleKernelModule.mod.o
  LD [M] /home/star/Desktop/testSimpleKernelModule/testSimpleKernelModule.ko
  BTF [M] /home/star/Desktop/testSimpleKernelModule/testSimpleKernelModule.ko
Skipping BTF generation for /home/star/Desktop/testSimpleKernelModule/testSimpleKernelModule.ko due to unavailability of vmlinux
make[1]: Leaving directory '/usr/src/linux-headers-5.13.0-35-generic'
star@ubuntu:~/Desktop/testSimpleKernelModule$
```





Then input **sudo insmod testSimpleKernelModule.ko**, which then prompt for the user password, then input **dmesg**,

```
star@ubuntu:~/Desktop/testSimpleKernelModule$ sudo insmod testSimpleKernelModule.ko
[sudo] password for star:
star@ubuntu:~/Desktop/testSimpleKernelModule$ dmesg
[    0.000000] Linux version 5.13.0-35-generic (buildd@ubuntu) (gcc (Ubuntu 9.3.0-17
ubuntu1~20.04) 9.3.0, GNU ld (GNU Binutils for Ubuntu) 2.34) #40~20.04.1-Ubuntu SMP
Mon Mar 7 09:18:32 UTC 2022 (Ubuntu 5.13.0-35.40~20.04.1-generic 5.13.19)
[    0.000000] Command line: BOOT_IMAGE=/boot/vmlinuz-5.13.0-35-generic root=UUID=de
b25d56-0e4e-4e57-8f2e-a20109906c13 ro find_preseed=/preseed.cfg auto noprompt priori
ty=critical locale=en_US quiet
[    0.000000] KERNEL supported cpus:
[    0.000000]   Intel GenuineIntel
[    0.000000]   AMD AuthenticAMD
[    0.000000]   Hygon HygonGenuine
[    0.000000]   Centaur CentaurHauls
```

After the **dmesg** command it will show the message “Hi, loading the module” or as shown below meaning that the kernel module is loaded.

```
[19957.594145] Hi, loading the module
```

Then input **sudo rmmod testSimpleKernelModule.ko**, and after that input **dmesg**,

```
star@ubuntu:~/Desktop/testSimpleKernelModule$ sudo rmmod testSimpleKernelModule.ko
star@ubuntu:~/Desktop/testSimpleKernelModule$ dmesg
[    0.000000] Linux version 5.13.0-35-generic (buildd@ubuntu) (gcc (Ubuntu 9.3.0-17
ubuntu1~20.04) 9.3.0, GNU ld (GNU Binutils for Ubuntu) 2.34) #40~20.04.1-Ubuntu SMP
Mon Mar 7 09:18:32 UTC 2022 (Ubuntu 5.13.0-35.40~20.04.1-generic 5.13.19)
[    0.000000] Command line: BOOT_IMAGE=/boot/vmlinuz-5.13.0-35-generic root=UUID=de
b25d56-0e4e-4e57-8f2e-a20109906c13 ro find_preseed=/preseed.cfg auto noprompt priori
ty=critical locale=en_US quiet
[    0.000000] KERNEL supported cpus:
[    0.000000]   Intel GenuineIntel
[    0.000000]   AMD AuthenticAMD
[    0.000000]   Hygon HygonGenuine
[    0.000000]   Centaur CentaurHauls
```

It will then show a message “Goodbye, removing the module” meaning that the module has been removed.

```
[20689.765850] Goodbye, removing the module
```

To sum up, the input command are as follows, **make** → **sudo insmod testSimpleKernelModule.ko** → **dmesg** → **sudo rmmod testSimpleKernelModule.ko** → **dmesg**, which produces the result as shown below of creating, loading and removing kernel modules or create the kernel module and to load and unload the module.

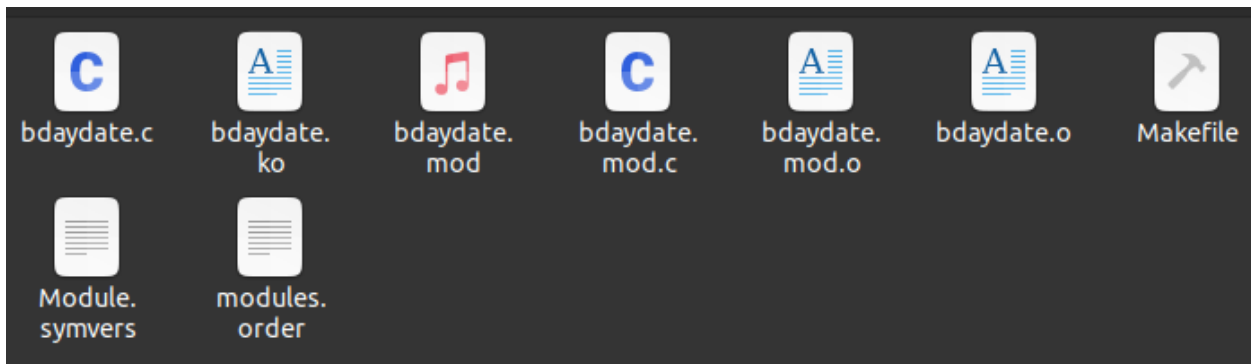
```
[19957.594145] Hi, loading the module
[20689.765850] Goodbye, removing the module
```

## Programming Project for Chap. 2

### Part II

1. Open chap2\_2 folder and open the terminal on the folder or either in the IDE used. (The screenshots attached for this part used Atom as IDE.)
2. Type make in the terminal to generate another seven files.

```
irene@ubuntu:~/Desktop/chap2_2$ make
make -C /usr/src/linux-headers-5.13.0-37-generic M=/home/irene/Desktop/chap2_2 modules
make[1]: Entering directory '/usr/src/linux-headers-5.13.0-37-generic'
CC [M] /home/irene/Desktop/chap2_2/bdaydate.o
MODPOST /home/irene/Desktop/chap2_2/Module.symvers
CC [M] /home/irene/Desktop/chap2_2/bdaydate.mod.o
LD [M] /home/irene/Desktop/chap2_2/bdaydate.ko
BTF [M] /home/irene/Desktop/chap2_2/bdaydate.ko
Skipping BTF generation for /home/irene/Desktop/chap2_2/bdaydate.ko due to unavailability of vmlinux
make[1]: Leaving directory '/usr/src/linux-headers-5.13.0-37-generic'
```



3. To create a birthday list:  
Type in `sudo insmod bdaydate.ko`, which will then ask you for the administrator password. After typing in the password is done, type in `dmesg`. After the commands are entered, the birthday list will be generated:

```
irene@ubuntu:~/Desktop/chap2_2$ sudo insmod bdaydate.ko
[sudo] password for irene:
irene@ubuntu:~/Desktop/chap2_2$ dmesg
```

```
[ 105.585544] Creating birthday list
[ 105.585545] Adding Starvian's birthday which is 1/6/2001
[ 105.585546] Adding Irene's birthday which is 2/7/2001
[ 105.585565] Adding Matti's birthday which is 3/8/2002
[ 105.585565] Adding Ken's birthday which is 4/9/2003
[ 105.585566] Adding Harvey's birthday which is 5/10/2004
```

To remove a birthday list:

Type in `sudo rmmod bdaydate.ko`. And type in `dmesg` right after that. After the commands are entered, the birthdate list will be removed from the kernel modules `sudo`.

```
irene@ubuntu:~/Desktop/chap2_2$ sudo rmmod bdaydate.ko
irene@ubuntu:~/Desktop/chap2_2$ dmesg

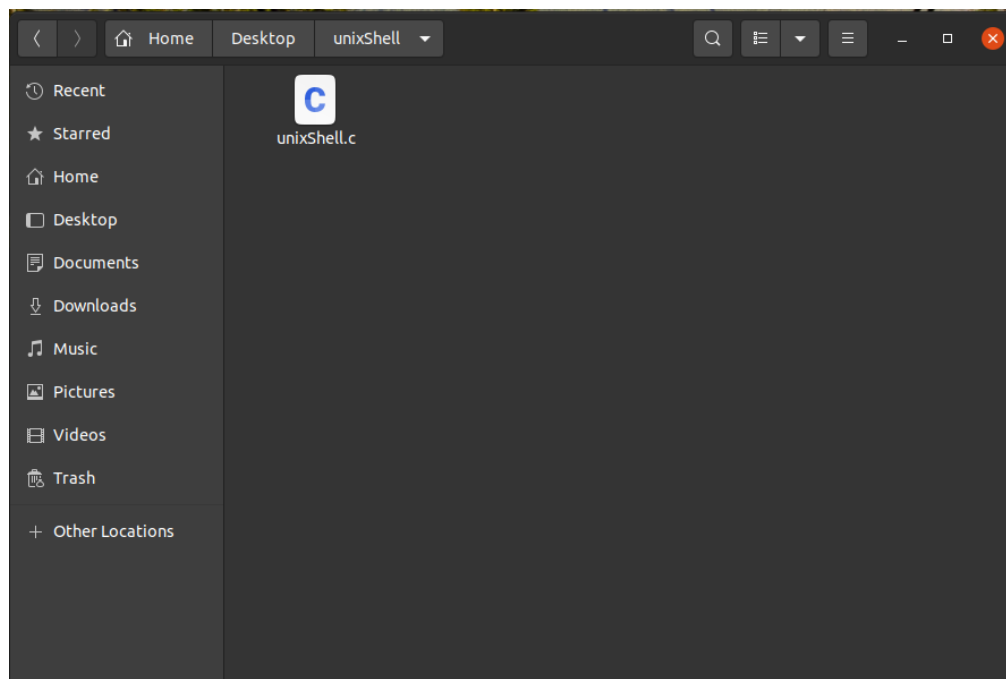
[ 105.585544] Creating birthday list
[ 105.585545] Adding Starvian's birthday which is 1/6/2001
[ 105.585546] Adding Irene's birthday which is 2/7/2001
[ 105.585565] Adding Matti's birthday which is 3/8/2002
[ 105.585565] Adding Ken's birthday which is 4/9/2003
[ 105.585566] Adding Harvey's birthday which is 5/10/2004
[ 146.034166] Removing birthday list
[ 146.034168] Removing Starvian's birthday which is 1/6/2001
[ 146.034169] Removing Irene's birthday which is 2/7/2001
[ 146.034170] Removing Matti's birthday which is 3/8/2002
[ 146.034171] Removing Ken's birthday which is 4/9/2003
[ 146.034171] Removing Harvey's birthday which is 5/10/2004
```

## Programming Project for Chap. 3

### Project 1

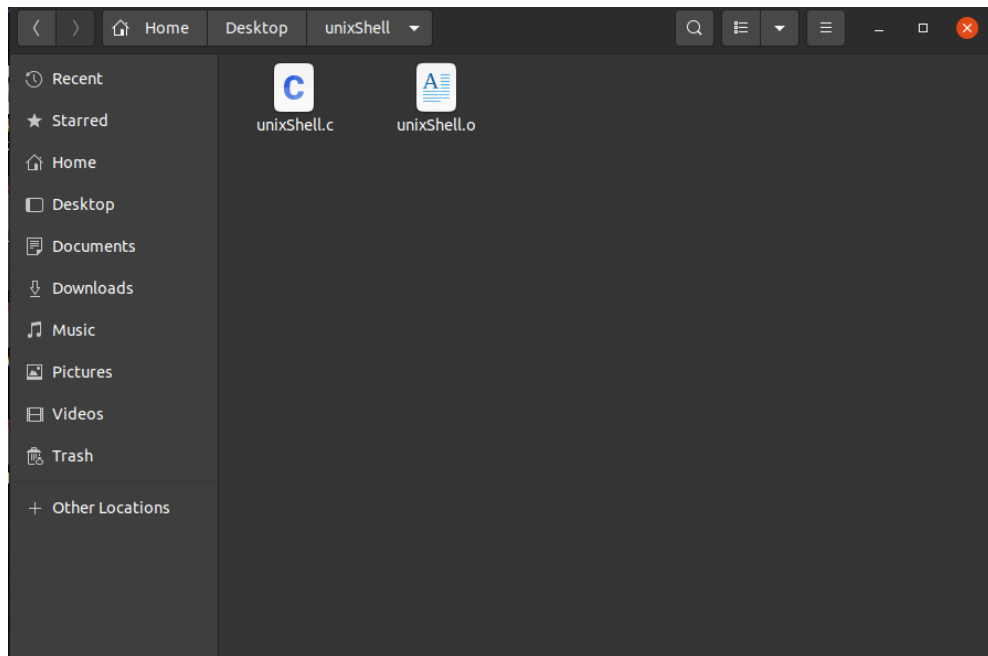
#### Part I

In Linux, go to the `unixShell` folder, then open the linux terminal inside of the folder,



Then input `gcc -g unixShell.c -o unixShell.o`, and then input `./unixShell.o`, and the `osh>` prompt will come out.

```
star@ubuntu:~/Desktop/unixShell$ gcc -g unixShell.c -o unixShell.o
star@ubuntu:~/Desktop/unixShell$ ./unixShell.o
osh>
```



Then input commands in the `osh>` prompt,

```
star@ubuntu:~/Desktop/unixShell$ gcc -g unixShell.c -o unixShell.o
star@ubuntu:~/Desktop/unixShell$ ./unixShell.o
osh> ls
unixShell.c  unixShell.o
osh> cd
execvp error
osh> cd ..
execvp error
osh> ls
unixShell.c  unixShell.o
osh> sd
execvp error
osh> ls
unixShell.c  unixShell.o
osh> ps
  PID TTY          TIME CMD
  7303 pts/0        00:00:00 bash
  7316 pts/0        00:00:00 unixShell.o
  7323 pts/0        00:00:00 ps
osh> ls
unixShell.c  unixShell.o
osh> cat newFile.txt
cat: newFile.txt: No such file or directory
osh> ls
unixShell.c  unixShell.o
osh> touch newFile.txt
osh> ls
newFile.txt  unixShell.c  unixShell.o
osh> cat newFile.txt
osh> rm newFile.txt
osh> ls
unixShell.c  unixShell.o
osh>
```

## Programming Project for Chap. 3

### Project 1

#### Part II

For the history feature, input **history**,

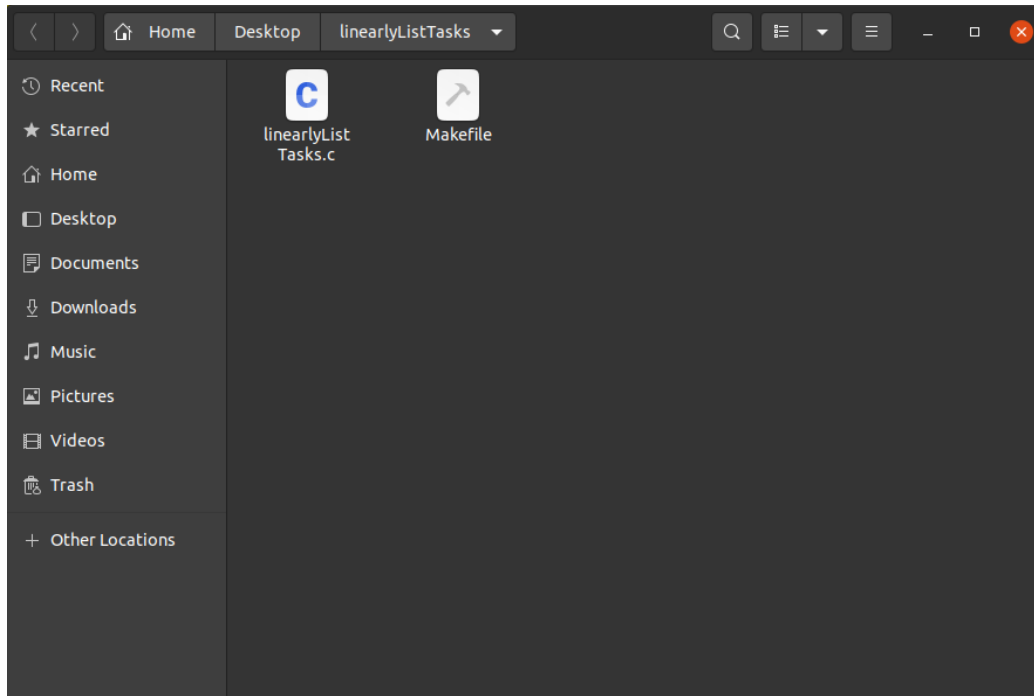
```
star@ubuntu:~/Desktop/unixShell$ gcc -g unixShell.c -o unixShell.o
star@ubuntu:~/Desktop/unixShell$ ./unixShell.o
osh> !!
No commands in history
osh> history
osh> ls
unixShell.c  unixShell.o
osh> cd
execvp error
osh> cd ..
execvp error
osh> ls
unixShell.c  unixShell.o
osh> sd
execvp error
osh> ls
unixShell.c  unixShell.o
osh> ps
  PID TTY          TIME CMD
  7365 pts/0        00:00:00 bash
  7378 pts/0        00:00:00 unixShell.o
  7388 pts/0        00:00:00 ps
osh> ls
unixShell.c  unixShell.o
osh> cat newFile.txt
cat: newFile.txt: No such file or directory
osh> ls
unixShell.c  unixShell.o
osh> touch newFile.txt
osh> ls
newFile.txt  unixShell.c  unixShell.o
osh> cat newFile.txt
osh> rm newFile.txt
osh> ls
unixShell.c  unixShell.o
osh> history
15 ls
14 rm newFile.txt
13 cat newFile.txt
12 ls
11 touch newFile.txt
10 ls
9 cat newFile.txt
8 ls
7 ps
6 ls
5 sd
4 ls
3 cd ..
2 cd
1 ls
osh> exit
star@ubuntu:~/Desktop/unixShell$
```

## Programming Project for Chap. 3

### Project 2

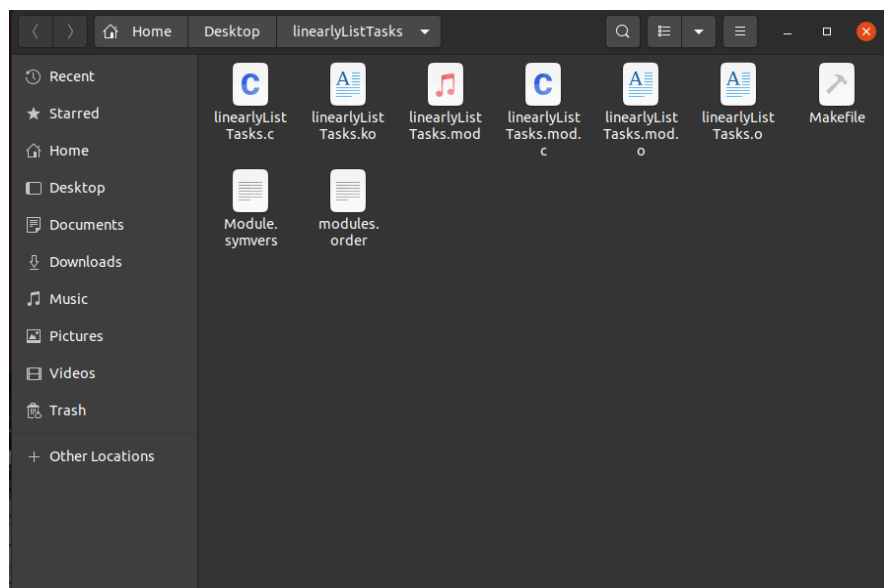
#### Part I

In Linux, go to the linearlyListTasks folder, then open the linux terminal inside of the folder,



Then input **make** in the terminal, where it will produce several files,

```
star@ubuntu:~/Desktop/linearlyListTasks$ make
make -C /usr/src/linux-headers-5.13.0-35-generic M=/home/star/Desktop/linearlyListTasks modules
make[1]: Entering directory '/usr/src/linux-headers-5.13.0-35-generic'
  CC [M] /home/star/Desktop/linearlyListTasks/linearlyListTasks.o
  MODPOST /home/star/Desktop/linearlyListTasks/Module.symvers
  CC [M] /home/star/Desktop/linearlyListTasks/linearlyListTasks.mod.o
  LD [M] /home/star/Desktop/linearlyListTasks/linearlyListTasks.ko
  BTF [M] /home/star/Desktop/linearlyListTasks/linearlyListTasks.ko
Skipping BTF generation for /home/star/Desktop/linearlyListTasks/linearlyListTasks.ko due to unavailability of vmlinux
make[1]: Leaving directory '/usr/src/linux-headers-5.13.0-35-generic'
star@ubuntu:~/Desktop/linearlyListTasks$
```



Then input **sudo insmod linearlyListTasks.ko**, which then prompt for the user password and after that input **dmesg**,

```
star@ubuntu:~/Desktop/linearlyListTasks$ sudo insmod linearlyListTasks.ko
[sudo] password for star:
star@ubuntu:~/Desktop/linearlyListTasks$ dmesg
[    0.000000] Linux version 5.13.0-35-generic (buildd@ubuntu) (gcc (Ubuntu 9.3.0-17ubuntu1~20.04) 9.3.0, GNU ld (GNU Binutils
for Ubuntu) 2.34) #40~20.04.1-Ubuntu SMP Mon Mar 7 09:18:32 UTC 2022 (Ubuntu 5.13.0-35.40~20.04.1-generic 5.13.19)
[    0.000000] Command line: BOOT_IMAGE=/boot/vmlinuz-5.13.0-35-generic root=UUID=deb25d56-0e4e-4e57-8f2e-a20109906c13 ro find
_preseed=/preseed.cfg auto noprompt priority=critical locale=en_US quiet
[    0.000000] KERNEL supported cpus:
[    0.000000]   Intel GenuineIntel
[    0.000000]   AMD AuthenticAMD
[    0.000000]   Hygon HygonGenuine
[    0.000000]   Centaur CentaurHauls
```

which then will show all of the current task listed linearly,

```
[12168.557142] Listing all of the current tasks linearly
[12168.557145] Task name: systemd, State: 1, pid: 1
[12168.557147] Task name: kthreadd, State: 1, pid: 2
[12168.557148] Task name: rcu_gp, State: 1026, pid: 3
[12168.557149] Task name: rcu_par_gp, State: 1026, pid: 4
[12168.557150] Task name: kworker/0:0H, State: 1026, pid: 6
[12168.557150] Task name: mm_percpu_wq, State: 1026, pid: 9
[12168.557151] Task name: rcu_tasks_rude_, State: 1, pid: 10
[12168.557152] Task name: rcu_tasks_trace, State: 1, pid: 11
[12168.557153] Task name: ksoftirqd/0, State: 1, pid: 12
[12168.557154] Task name: rcu_sched, State: 1026, pid: 13
[12168.557155] Task name: migration/0, State: 1, pid: 14
[12168.557155] Task name: idle_inject/0, State: 1, pid: 15
[12168.557156] Task name: cpuhp/0, State: 1, pid: 16
[12168.557157] Task name: cpuhp/1, State: 1, pid: 17
[12168.557158] Task name: idle_inject/1, State: 1, pid: 18
[12168.557159] Task name: migration/1, State: 1, pid: 19
[12168.557159] Task name: ksoftirqd/1, State: 1, pid: 20
[12168.557160] Task name: kworker/1:0H, State: 1026, pid: 22
[12168.557161] Task name: cpuhp/2, State: 1, pid: 23
[12168.557162] Task name: idle_inject/2, State: 1, pid: 24
[12168.557162] Task name: migration/2, State: 1, pid: 25
[12168.557163] Task name: ksoftirqd/2, State: 1, pid: 26
[12168.557164] Task name: kworker/2:0H, State: 1026, pid: 28
[12168.557165] Task name: cpuhp/3, State: 1, pid: 29
[12168.557166] Task name: idle_inject/3, State: 1, pid: 30
[12168.557166] Task name: migration/3, State: 1, pid: 31
[12168.557167] Task name: ksoftirqd/3, State: 1, pid: 32
[12168.557168] Task name: kworker/3:0H, State: 1026, pid: 34
[12168.557169] Task name: kdevtmpfs, State: 1, pid: 35
[12168.557188] Task name: netns, State: 1026, pid: 36
[12168.557189] Task name: inet_frag_wq, State: 1026, pid: 37
[12168.557190] Task name: kauditd, State: 1, pid: 38
[12168.557190] Task name: khungtaskd, State: 1, pid: 40
[12168.557191] Task name: oom_reaper, State: 1, pid: 41
[12168.557192] Task name: writeback, State: 1026, pid: 42
[12168.557193] Task name: kcompactd0, State: 1, pid: 43
[12168.557194] Task name: ksm, State: 1, pid: 44
[12168.557227] Task name: khugepaged, State: 1, pid: 45
[12168.557229] Task name: kintegrityd, State: 1026, pid: 94
[12168.557230] Task name: kblockd, State: 1026, pid: 95
[12168.557231] Task name: blkcg_punt_bio, State: 1026, pid: 96
[12168.557232] Task name: tpm_dev_wq, State: 1026, pid: 97
[12168.557232] Task name: ata_sff, State: 1026, pid: 98
[12168.557233] Task name: md, State: 1026, pid: 99
[12168.557234] Task name: edac-poller, State: 1026, pid: 100
[12168.557235] Task name: devfreq_wq, State: 1026, pid: 101
```



Then at the bottom it will show a message which means it has done listing all of the current tasks linearly,

```
[13101.309880] Task name: xdg-desktop-por, State: 1, pid: 2108
[13101.309881] Task name: xdg-desktop-por, State: 1, pid: 2112
[13101.309882] Task name: Socket Process, State: 1, pid: 2140
[13101.309882] Task name: Privileged Cont, State: 1, pid: 2181
[13101.309883] Task name: Isolated Web Co, State: 1, pid: 2204
[13101.309884] Task name: WebExtensions, State: 1, pid: 2262
[13101.309885] Task name: RDD Process, State: 1, pid: 2388
[13101.309886] Task name: update-notifier, State: 1, pid: 2395
[13101.309886] Task name: gvfsd-network, State: 1, pid: 2611
[13101.309887] Task name: gvfsd-dnssd, State: 1, pid: 2775
[13101.309888] Task name: Web Content, State: 1, pid: 3441
[13101.309889] Task name: Web Content, State: 1, pid: 3476
[13101.309889] Task name: Web Content, State: 1, pid: 3497
[13101.309890] Task name: nautilus, State: 1, pid: 3559
[13101.309891] Task name: kworker/u257:2, State: 1026, pid: 6210
[13101.309892] Task name: fwupd, State: 1, pid: 6226
[13101.309893] Task name: gnome-control-c, State: 1, pid: 7431
[13101.309893] Task name: kworker/3:2, State: 1026, pid: 7980
[13101.309894] Task name: kworker/u257:0, State: 1026, pid: 8053
[13101.309909] Task name: cupsd, State: 1, pid: 8068
[13101.309911] Task name: cups-browsed, State: 1, pid: 8070
[13101.309911] Task name: kworker/2:1, State: 1026, pid: 8579
[13101.309912] Task name: xfsalloc, State: 1026, pid: 15741
[13101.309913] Task name: xfs_mru_cache, State: 1026, pid: 15742
[13101.309914] Task name: jfsIO, State: 1, pid: 15746
[13101.309915] Task name: jfsCommit, State: 1, pid: 15747
[13101.309916] Task name: jfsCommit, State: 1, pid: 15748
[13101.309916] Task name: jfsCommit, State: 1, pid: 15749
[13101.309917] Task name: jfsCommit, State: 1, pid: 15750
[13101.309918] Task name: jfsSync, State: 1, pid: 15751
[13101.309919] Task name: kworker/0:0, State: 1026, pid: 15920
[13101.309920] Task name: kworker/3:0, State: 1026, pid: 18591
[13101.309921] Task name: kworker/0:1, State: 1026, pid: 18597
[13101.309921] Task name: kworker/u256:0, State: 1026, pid: 18616
[13101.309922] Task name: kworker/1:0, State: 1026, pid: 18628
[13101.309923] Task name: gedit, State: 1, pid: 19191
[13101.309924] Task name: kworker/2:0, State: 1026, pid: 19637
[13101.309924] Task name: kworker/u256:1, State: 1026, pid: 20083
[13101.309939] Task name: kworker/1:1, State: 1026, pid: 20162
[13101.309940] Task name: kworker/u256:2, State: 1026, pid: 20163
[13101.309941] Task name: gnome-terminal-, State: 1, pid: 20193
[13101.309941] Task name: bash, State: 1, pid: 20201
[13101.309942] Task name: kworker/u256:3, State: 1026, pid: 20626
[13101.309943] Task name: kworker/1:2, State: 1026, pid: 20644
[13101.309944] Task name: sudo, State: 1, pid: 20645
[13101.309944] Task name: insmod, State: 0, pid: 20646
[13101.309945] All of the current tasks are listed linearly
star@ubuntu:~/Desktop/linearlyListTasks$
```

Then input **sudo rmmod linearlyListTasks.ko**, and after that input **dmesg**,

```
star@ubuntu:~/Desktop/starHW105/linearlyListTasks$ sudo rmmod linearlyListTasks.ko
star@ubuntu:~/Desktop/starHW105/linearlyListTasks$ dmesg
[ 0.000000] Linux version 5.13.0-35-generic (buildd@ubuntu) (gcc (Ubuntu 9.3.0-17ubuntu1~20.04) 9.3.0, GNU ld (GNU Binutils
for Ubuntu) 2.34) #40~20.04.1-Ubuntu SMP Mon Mar 7 09:18:32 UTC 2022 (Ubuntu 5.13.0-35.40~20.04.1-generic 5.13.19)
[ 0.000000] Command line: BOOT_IMAGE=/boot/vmlinuz-5.13.0-35-generic root=UUID=deb25d56-0e4e-4e57-8f2e-a20109906c13 ro find
_preseed=/preseed.cfg auto noprompt priority=critical locale=en_US quiet
[ 0.000000] KERNEL supported cpus:
[ 0.000000] Intel GenuineIntel
[ 0.000000] AMD AuthenticAMD
[ 0.000000] Hygon HygonGenuine
[ 0.000000] Centaur CentaurHauls
```



Then, there will be a message “Goodbye” in the bottom which means that the module has been removed.

```
[13101.309881] Task name: xdg-desktop-por, State: 1, pid: 2112
[13101.309882] Task name: Socket Process, State: 1, pid: 2140
[13101.309882] Task name: Privileged Cont, State: 1, pid: 2181
[13101.309883] Task name: Isolated Web Co, State: 1, pid: 2204
[13101.309884] Task name: WebExtensions, State: 1, pid: 2262
[13101.309885] Task name: RDD Process, State: 1, pid: 2388
[13101.309886] Task name: update-notifier, State: 1, pid: 2395
[13101.309886] Task name: gvfsd-network, State: 1, pid: 2611
[13101.309887] Task name: gvfsd-dnssd, State: 1, pid: 2775
[13101.309888] Task name: Web Content, State: 1, pid: 3441
[13101.309889] Task name: Web Content, State: 1, pid: 3476
[13101.309889] Task name: Web Content, State: 1, pid: 3497
[13101.309890] Task name: nautilus, State: 1, pid: 3559
[13101.309891] Task name: kworker/u257:2, State: 1026, pid: 6210
[13101.309892] Task name: fwupd, State: 1, pid: 6226
[13101.309893] Task name: gnome-control-c, State: 1, pid: 7431
[13101.309893] Task name: kworker/3:2, State: 1026, pid: 7980
[13101.309894] Task name: kworker/u257:0, State: 1026, pid: 8053
[13101.309909] Task name: cupsd, State: 1, pid: 8068
[13101.309911] Task name: cups-browsed, State: 1, pid: 8070
[13101.309911] Task name: kworker/2:1, State: 1026, pid: 8579
[13101.309912] Task name: xfsalloc, State: 1026, pid: 15741
[13101.309913] Task name: xfs_mru_cache, State: 1026, pid: 15742
[13101.309914] Task name: jfsIO, State: 1, pid: 15746
[13101.309915] Task name: jfsCommit, State: 1, pid: 15747
[13101.309916] Task name: jfsCommit, State: 1, pid: 15748
[13101.309916] Task name: jfsCommit, State: 1, pid: 15749
[13101.309917] Task name: jfsCommit, State: 1, pid: 15750
[13101.309918] Task name: jfsSync, State: 1, pid: 15751
[13101.309919] Task name: kworker/0:0, State: 1026, pid: 15920
[13101.309920] Task name: kworker/3:0, State: 1026, pid: 18591
[13101.309921] Task name: kworker/0:1, State: 1026, pid: 18597
[13101.309921] Task name: kworker/u256:0, State: 1026, pid: 18616
[13101.309922] Task name: kworker/1:0, State: 1026, pid: 18628
[13101.309923] Task name: gedit, State: 1, pid: 19191
[13101.309924] Task name: kworker/2:0, State: 1026, pid: 19637
[13101.309924] Task name: kworker/u256:1, State: 1026, pid: 20083
[13101.309939] Task name: kworker/1:1, State: 1026, pid: 20162
[13101.309940] Task name: kworker/u256:2, State: 1026, pid: 20163
[13101.309941] Task name: gnome-terminal-, State: 1, pid: 20193
[13101.309941] Task name: bash, State: 1, pid: 20201
[13101.309942] Task name: kworker/u256:3, State: 1026, pid: 20626
[13101.309943] Task name: kworker/1:2, State: 1026, pid: 20644
[13101.309944] Task name: sudo, State: 1, pid: 20645
[13101.309944] Task name: insmod, State: 0, pid: 20646
[13101.309945] All of the current tasks are listed linearly
[14106.537926] Goodbye
star@ubuntu:~/Desktop/linearlyListTasks$
```

To sum up, the input command are as follows, **make** → **sudo insmod linearlyListTasks.ko** → **dmesg** → **sudo rmmod linearlyListTasks.ko** → **dmesg**, which produces the result which is a kernel module that lists all of the current tasks in a Linux system linearly or as shown below,

```
[12168.557142] Listing all of the current tasks linearly
[12168.557145] Task name: systemd, State: 1, pid: 1
[12168.557147] Task name: kthreadd, State: 1, pid: 2
[12168.557148] Task name: rcu_gp, State: 1026, pid: 3
[12168.557149] Task name: rcu_par_gp, State: 1026, pid: 4
[12168.557150] Task name: kworker/0:0H, State: 1026, pid: 6
[12168.557150] Task name: mm_percpu_wq, State: 1026, pid: 9
[12168.557151] Task name: rcu_tasks_rude_, State: 1, pid: 10
[12168.557152] Task name: rcu_tasks_trace, State: 1, pid: 11
[12168.557153] Task name: ksoftirqd/0, State: 1, pid: 12
[12168.557154] Task name: rcu_sched, State: 1026, pid: 13
[12168.557155] Task name: migration/0, State: 1, pid: 14
[12168.557155] Task name: idle_inject/0, State: 1, pid: 15
[12168.557156] Task name: cpuhp/0, State: 1, pid: 16
[12168.557157] Task name: cpuhp/1, State: 1, pid: 17
[12168.557158] Task name: idle_inject/1, State: 1, pid: 18
[12168.557159] Task name: migration/1, State: 1, pid: 19
[12168.557159] Task name: ksoftirqd/1, State: 1, pid: 20
[12168.557160] Task name: kworker/1:0H, State: 1026, pid: 22
[12168.557161] Task name: cpuhp/2, State: 1, pid: 23
[12168.557162] Task name: idle_inject/2, State: 1, pid: 24
[12168.557162] Task name: migration/2, State: 1, pid: 25
[12168.557163] Task name: ksoftirqd/2, State: 1, pid: 26
[12168.557164] Task name: kworker/2:0H, State: 1026, pid: 28
[12168.557165] Task name: cpuhp/3, State: 1, pid: 29
[12168.557166] Task name: idle_inject/3, State: 1, pid: 30
[12168.557166] Task name: migration/3, State: 1, pid: 31
[12168.557167] Task name: ksoftirqd/3, State: 1, pid: 32
[12168.557168] Task name: kworker/3:0H, State: 1026, pid: 34
[12168.557169] Task name: kdevtmpfs, State: 1, pid: 35
[12168.557188] Task name: netns, State: 1026, pid: 36
[12168.557189] Task name: inet_frag_wq, State: 1026, pid: 37
[12168.557190] Task name: kauditd, State: 1, pid: 38
[12168.557190] Task name: khungtaskd, State: 1, pid: 40
[12168.557191] Task name: oom_reaper, State: 1, pid: 41
[12168.557192] Task name: writeback, State: 1026, pid: 42
[12168.557193] Task name: kcompactd0, State: 1, pid: 43
[12168.557194] Task name: ksmd, State: 1, pid: 44
[12168.557227] Task name: khugepaged, State: 1, pid: 45
[12168.557229] Task name: kintegrityd, State: 1026, pid: 94
[12168.557230] Task name: kblockd, State: 1026, pid: 95
[12168.557231] Task name: blkcg_punt_bio, State: 1026, pid: 96
[12168.557232] Task name: tpm_dev_wq, State: 1026, pid: 97
[12168.557232] Task name: ata_sff, State: 1026, pid: 98
[12168.557233] Task name: md, State: 1026, pid: 99
[12168.557234] Task name: edac-poller, State: 1026, pid: 100
[12168.557235] Task name: devfreq_wq, State: 1026, pid: 101
```

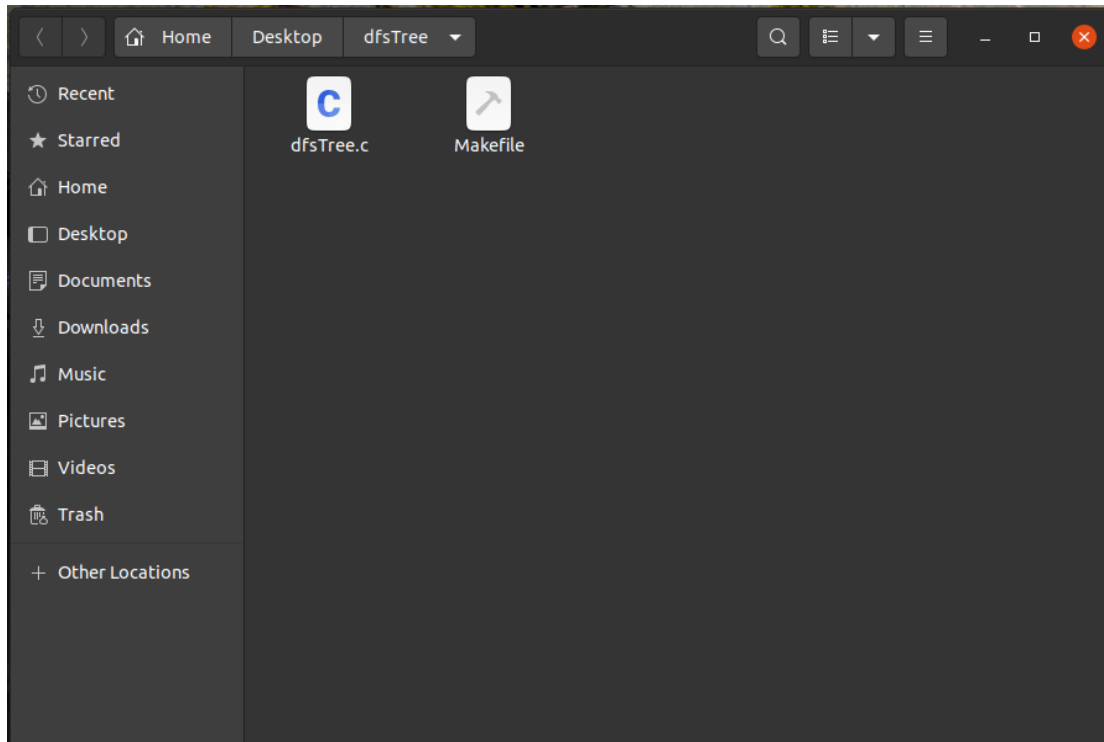
```
[13101.309881] Task name: xdg-desktop-por, State: 1, pid: 2112
[13101.309882] Task name: Socket Process, State: 1, pid: 2140
[13101.309882] Task name: Privileged Cont, State: 1, pid: 2181
[13101.309883] Task name: Isolated Web Co, State: 1, pid: 2204
[13101.309884] Task name: WebExtensions, State: 1, pid: 2262
[13101.309885] Task name: RDD Process, State: 1, pid: 2388
[13101.309886] Task name: update-notifier, State: 1, pid: 2395
[13101.309886] Task name: gvfsd-network, State: 1, pid: 2611
[13101.309887] Task name: gvfsd-dnssd, State: 1, pid: 2775
[13101.309888] Task name: Web Content, State: 1, pid: 3441
[13101.309889] Task name: Web Content, State: 1, pid: 3476
[13101.309889] Task name: Web Content, State: 1, pid: 3497
[13101.309890] Task name: nautilus, State: 1, pid: 3559
[13101.309891] Task name: kworker/u257:2, State: 1026, pid: 6210
[13101.309892] Task name: fwupd, State: 1, pid: 6226
[13101.309893] Task name: gnome-control-c, State: 1, pid: 7431
[13101.309893] Task name: kworker/3:2, State: 1026, pid: 7980
[13101.309894] Task name: kworker/u257:0, State: 1026, pid: 8053
[13101.309909] Task name: cupsd, State: 1, pid: 8068
[13101.309911] Task name: cups-browsed, State: 1, pid: 8070
[13101.309911] Task name: kworker/2:1, State: 1026, pid: 8579
[13101.309912] Task name: xfsalloc, State: 1026, pid: 15741
[13101.309913] Task name: xfs_mru_cache, State: 1026, pid: 15742
[13101.309914] Task name: jfsIO, State: 1, pid: 15746
[13101.309915] Task name: jfsCommit, State: 1, pid: 15747
[13101.309916] Task name: jfsCommit, State: 1, pid: 15748
[13101.309916] Task name: jfsCommit, State: 1, pid: 15749
[13101.309917] Task name: jfsCommit, State: 1, pid: 15750
[13101.309918] Task name: jfsSync, State: 1, pid: 15751
[13101.309919] Task name: kworker/0:0, State: 1026, pid: 15920
[13101.309920] Task name: kworker/3:0, State: 1026, pid: 18591
[13101.309921] Task name: kworker/0:1, State: 1026, pid: 18597
[13101.309921] Task name: kworker/u256:0, State: 1026, pid: 18616
[13101.309922] Task name: kworker/1:0, State: 1026, pid: 18628
[13101.309923] Task name: gedit, State: 1, pid: 19191
[13101.309924] Task name: kworker/2:0, State: 1026, pid: 19637
[13101.309924] Task name: kworker/u256:1, State: 1026, pid: 20083
[13101.309939] Task name: kworker/1:1, State: 1026, pid: 20162
[13101.309940] Task name: kworker/u256:2, State: 1026, pid: 20163
[13101.309941] Task name: gnome-terminal-, State: 1, pid: 20193
[13101.309941] Task name: bash, State: 1, pid: 20201
[13101.309942] Task name: kworker/u256:3, State: 1026, pid: 20626
[13101.309943] Task name: kworker/1:2, State: 1026, pid: 20644
[13101.309944] Task name: sudo, State: 1, pid: 20645
[13101.309944] Task name: insmod, State: 0, pid: 20646
[13101.309945] All of the current tasks are listed linearly
[14106.537926] Goodbye
star@ubuntu:~/Desktop/linearlyListTasks$
```

## Programming Project for Chap. 3

### Project 2

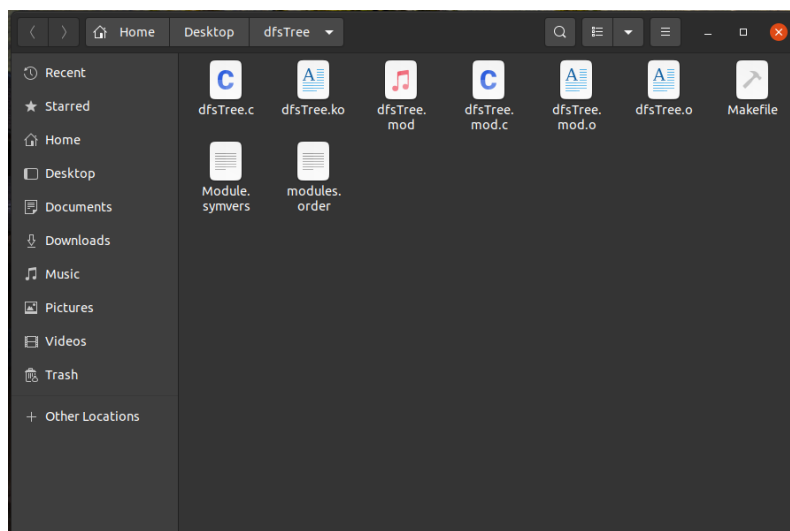
#### Part II

In Linux, go to the dfsTree folder, then open the linux terminal inside of the folder,



Then input **make** in the terminal, where it will produce several files,

```
star@ubuntu:~/Desktop/dfsTree$ make
make -C /usr/src/linux-headers-5.13.0-35-generic M=/home/star/Desktop/dfsTree modules
make[1]: Entering directory '/usr/src/linux-headers-5.13.0-35-generic'
  CC [M] /home/star/Desktop/dfsTree/dfsTree.o
  MODPOST /home/star/Desktop/dfsTree/Module.symvers
  CC [M] /home/star/Desktop/dfsTree/dfsTree.mod.o
  LD [M] /home/star/Desktop/dfsTree/dfsTree.ko
  BTF [M] /home/star/Desktop/dfsTree/dfsTree.ko
Skipping BTF generation for /home/star/Desktop/dfsTree/dfsTree.ko due to unavailability
of vmlinux
make[1]: Leaving directory '/usr/src/linux-headers-5.13.0-35-generic'
star@ubuntu:~/Desktop/dfsTree$
```



Then input **sudo insmod dfsTree.ko**, which then prompt for the user password and after that input **dmesg**,

```
star@ubuntu:~/Desktop/dfsTree$ sudo insmod dfsTree.ko
[sudo] password for star:
star@ubuntu:~/Desktop/dfsTree$ dmesg
[ 0.000000] Linux version 5.13.0-35-generic (buildd@ubuntu) (gcc (Ubuntu 9.3.0-17ubuntu1~20.04)
9.3.0, GNU ld (GNU Binutils for Ubuntu) 2.34) #40~20.04.1-Ubuntu SMP Mon Mar 7 09:18:32 UTC 2022
(Ubuntu 5.13.0-35.40~20.04.1-generic 5.13.19)
[ 0.000000] Command line: BOOT_IMAGE=/boot/vmlinuz-5.13.0-35-generic root=UUID=deb25d56-0e4e-4e
57-8f2e-a20109906c13 ro find_preseed=/preseed.cfg auto noprompt priority=critical locale=en_US qui
et
[ 0.000000] KERNEL supported cpus:
[ 0.000000] Intel GenuineIntel
[ 0.000000] AMD AuthenticAMD
[ 0.000000] Hygon HygonGenuine
[ 0.000000] Centaur CentaurHauls
```

which then will show all of the current task listed using a depth-first search(DFS) tree,

```
[28609.066316] Listing all of the current tasks using a depth-first search(DFS) tree
[28609.066323] task name: systemd, state: 1, pid: 1
[28609.066326] task name: systemd-journal, state: 0, pid: 377
[28609.066327] task name: systemd-udevd, state: 1, pid: 432
[28609.066328] task name: vmware-vmblock-, state: 1, pid: 442
[28609.066329] task name: systemd-resolve, state: 1, pid: 725
[28609.066330] task name: systemd-timesyn, state: 1, pid: 726
[28609.066331] task name: VGAuthService, state: 1, pid: 729
[28609.066332] task name: vmttoolsd, state: 1, pid: 731
[28609.066333] task name: accounts-daemon, state: 1, pid: 752
[28609.066334] task name: acpid, state: 1, pid: 753
[28609.066335] task name: avahi-daemon, state: 1, pid: 756
[28609.066336] task name: avahi-daemon, state: 1, pid: 803
[28609.066337] task name: bluetoothd, state: 1, pid: 757
[28609.066339] task name: cron, state: 1, pid: 758
[28609.066339] task name: dbus-daemon, state: 1, pid: 760
[28609.066341] task name: NetworkManager, state: 1, pid: 761
[28609.066343] task name: irqbalance, state: 1, pid: 766
[28609.066346] task name: networkd-dispat, state: 1, pid: 767
[28609.066412] task name: polkitd, state: 1, pid: 769
[28609.066415] task name: rsyslogd, state: 1, pid: 771
[28609.066416] task name: snapd, state: 1, pid: 772
[28609.066417] task name: switcheroo-cont, state: 1, pid: 773
[28609.066418] task name: systemd-logind, state: 1, pid: 774
[28609.066420] task name: udisksd, state: 1, pid: 775
[28609.066421] task name: wpa_supplicant, state: 1, pid: 776
[28609.066422] task name: ModemManager, state: 1, pid: 868
[28609.066423] task name: unattended-upgr, state: 1, pid: 874
[28609.066424] task name: gdm3, state: 1, pid: 897
[28609.066426] task name: gdm-session-wor, state: 1, pid: 1436
[28609.066427] task name: gdm-x-session, state: 1, pid: 1509
[28609.066428] task name: Xorg, state: 0, pid: 1516
[28609.066429] task name: gnome-session-b, state: 1, pid: 1558
[28609.066431] task name: ssh-agent, state: 1, pid: 1625
[28609.066432] task name: whoopsie, state: 1, pid: 993
[28609.066433] task name: kerneloops, state: 1, pid: 994
[28609.066435] task name: kerneloops, state: 1, pid: 996
[28609.066436] task name: systemd-network, state: 1, pid: 1014
[28609.066438] task name: rtkit-daemon, state: 1, pid: 1056
```



Then at the bottom it will show a message which means it has done listing all of the current tasks linearly,

```
[28609.076922] task name: ttm_swap, state: 1026, pid: 411
[28609.076923] task name: irq/16-vmwgfx, state: 1, pid: 412
[28609.076923] task name: card0-crtc0, state: 1, pid: 413
[28609.076924] task name: card0-crtc1, state: 1, pid: 414
[28609.076925] task name: card0-crtc2, state: 1, pid: 415
[28609.076926] task name: card0-crtc3, state: 1, pid: 416
[28609.076926] task name: card0-crtc4, state: 1, pid: 417
[28609.076927] task name: card0-crtc5, state: 1, pid: 418
[28609.076928] task name: card0-crtc6, state: 1, pid: 419
[28609.076928] task name: card0-crtc7, state: 1, pid: 420
[28609.076929] task name: loop6, state: 1, pid: 422
[28609.076930] task name: loop7, state: 1, pid: 424
[28609.076931] task name: loop8, state: 1, pid: 429
[28609.076931] task name: loop9, state: 1, pid: 430
[28609.076932] task name: loop10, state: 1, pid: 436
[28609.076946] task name: loop11, state: 1, pid: 440
[28609.076947] task name: loop12, state: 1, pid: 441
[28609.076947] task name: cryptd, state: 1026, pid: 568
[28609.085952] task name: krfcomm, state: 1, pid: 1539
[28609.085957] task name: kworker/u257:2, state: 1026, pid: 6210
[28609.085959] task name: kworker/u257:0, state: 1026, pid: 8053
[28609.085961] task name: xfsalloc, state: 1026, pid: 15741
[28609.085962] task name: xfs_mru_cache, state: 1026, pid: 15742
[28609.085965] task name: jfsIO, state: 1, pid: 15746
[28609.085968] task name: jfsCommit, state: 1, pid: 15747
[28609.085970] task name: jfsCommit, state: 1, pid: 15748
[28609.085973] task name: jfsCommit, state: 1, pid: 15749
[28609.085975] task name: jfsCommit, state: 1, pid: 15750
[28609.085976] task name: jfsSync, state: 1, pid: 15751
[28609.085978] task name: kworker/1:0, state: 0, pid: 25533
[28609.085980] task name: kworker/u256:0, state: 1026, pid: 27945
[28609.085982] task name: kworker/3:3, state: 1026, pid: 28018
[28609.085984] task name: kworker/0:1, state: 1026, pid: 28095
[28609.085986] task name: kworker/2:1, state: 1026, pid: 28117
[28609.085988] task name: kworker/u256:1, state: 1026, pid: 28149
[28609.085989] task name: kworker/3:0, state: 1026, pid: 28163
[28609.085991] task name: kworker/0:2, state: 1026, pid: 28168
[28609.085992] task name: kworker/u256:2, state: 1026, pid: 28179
[28609.086101] task name: kworker/1:1, state: 1026, pid: 28208
[28609.086102] task name: kworker/2:2, state: 1026, pid: 28212
[28609.086105] task name: kworker/2:0, state: 1026, pid: 29449
[28609.086106] task name: kworker/u256:3, state: 1026, pid: 29463
[28609.086108] All of the current tasks are listed using a depth-first search(DFS) tree
star@ubuntu:~/Desktop/dfsTree$
```

Then input **sudo rmmod dfsTree.ko**, and after that input **dmesg**,

```
star@ubuntu:~/Desktop/dfsTree$ sudo rmmod dfsTree.ko
star@ubuntu:~/Desktop/dfsTree$ dmesg
[ 0.000000] Linux version 5.13.0-35-generic (build@ubuntu) (gcc (Ubuntu 9.3.0-17ubuntu1~20.04) 9.3.0, GNU ld (GNU Binutils
for Ubuntu) 2.34) #40~20.04.1-Ubuntu SMP Mon Mar 7 09:18:32 UTC 2022 (Ubuntu 5.13.0-35.40~20.04.1-generic 5.13.19)
[ 0.000000] Command line: BOOT_IMAGE=/boot/vmlinuz-5.13.0-35-generic root=UUID=deb25d56-0e4e-4e57-8f2e-a20109906c13 ro find
_preseed=/preseed.cfg auto noprompt priority=critical locale=en_US quiet
[ 0.000000] KERNEL supported cpus:
[ 0.000000] Intel GenuineIntel
[ 0.000000] AMD AuthenticAMD
[ 0.000000] Hygon HygonGenuine
[ 0.000000] Centaur CentaurHauls
```

Then, there will be a message “Goodbye” in the bottom which means that the module has been removed.

```
[28609.076923] task name: irq/16-vmwgfx, state: 1, pid: 412
[28609.076923] task name: card0-crtc0, state: 1, pid: 413
[28609.076924] task name: card0-crtc1, state: 1, pid: 414
[28609.076925] task name: card0-crtc2, state: 1, pid: 415
[28609.076926] task name: card0-crtc3, state: 1, pid: 416
[28609.076926] task name: card0-crtc4, state: 1, pid: 417
[28609.076927] task name: card0-crtc5, state: 1, pid: 418
[28609.076928] task name: card0-crtc6, state: 1, pid: 419
[28609.076928] task name: card0-crtc7, state: 1, pid: 420
[28609.076929] task name: loop6, state: 1, pid: 422
[28609.076930] task name: loop7, state: 1, pid: 424
[28609.076931] task name: loop8, state: 1, pid: 429
[28609.076931] task name: loop9, state: 1, pid: 430
[28609.076932] task name: loop10, state: 1, pid: 436
[28609.076946] task name: loop11, state: 1, pid: 440
[28609.076947] task name: loop12, state: 1, pid: 441
[28609.076947] task name: cryptd, state: 1026, pid: 568
[28609.085952] task name: krfcommd, state: 1, pid: 1539
[28609.085957] task name: kworker/u257:2, state: 1026, pid: 6210
[28609.085959] task name: kworker/u257:0, state: 1026, pid: 8053
[28609.085961] task name: xfsalloc, state: 1026, pid: 15741
[28609.085962] task name: xfs_mru_cache, state: 1026, pid: 15742
[28609.085965] task name: jfsIO, state: 1, pid: 15746
[28609.085968] task name: jfsCommit, state: 1, pid: 15747
[28609.085970] task name: jfsCommit, state: 1, pid: 15748
[28609.085973] task name: jfsCommit, state: 1, pid: 15749
[28609.085975] task name: jfsCommit, state: 1, pid: 15750
[28609.085976] task name: jfsSync, state: 1, pid: 15751
[28609.085978] task name: kworker/1:0, state: 0, pid: 25533
[28609.085980] task name: kworker/u256:0, state: 1026, pid: 27945
[28609.085982] task name: kworker/3:3, state: 1026, pid: 28018
[28609.085984] task name: kworker/0:1, state: 1026, pid: 28095
[28609.085986] task name: kworker/2:1, state: 1026, pid: 28117
[28609.085988] task name: kworker/u256:1, state: 1026, pid: 28149
[28609.085989] task name: kworker/3:0, state: 1026, pid: 28163
[28609.085991] task name: kworker/0:2, state: 1026, pid: 28168
[28609.085992] task name: kworker/u256:2, state: 1026, pid: 28179
[28609.086101] task name: kworker/1:1, state: 1026, pid: 28208
[28609.086102] task name: kworker/2:2, state: 1026, pid: 28212
[28609.086105] task name: kworker/2:0, state: 1026, pid: 29449
[28609.086106] task name: kworker/u256:3, state: 1026, pid: 29463
[28609.086108] All of the current tasks are listed using a depth-first search(DFS) tree
[29924.024482] Goodbye
star@ubuntu:~/Desktop/dfsTree$
```

To sum up, the input command are as follows, **make** → **sudo insmod dfsTree.ko** → **dmesg** → **sudo rmmod dfsTree.ko** → **dmesg**, which produces the result which is a kernel module that lists all of the current tasks in a Linux system with a depth-first search(DFS) tree or as shown below,

```
[28609.066316] Listing all of the current tasks using a depth-first search(DFS) tree
[28609.066323] task name: systemd, state: 1, pid: 1
[28609.066326] task name: systemd-journal, state: 0, pid: 377
[28609.066327] task name: systemd-udev, state: 1, pid: 432
[28609.066328] task name: vmware-vmblock-, state: 1, pid: 442
[28609.066329] task name: systemd-resolve, state: 1, pid: 725
[28609.066330] task name: systemd-timesyn, state: 1, pid: 726
[28609.066331] task name: VGAuthService, state: 1, pid: 729
[28609.066332] task name: vmtoolsd, state: 1, pid: 731
[28609.066333] task name: accounts-daemon, state: 1, pid: 752
[28609.066334] task name: acpid, state: 1, pid: 753
[28609.066335] task name: avahi-daemon, state: 1, pid: 756
[28609.066336] task name: avahi-daemon, state: 1, pid: 803
[28609.066337] task name: bluetoothd, state: 1, pid: 757
[28609.066339] task name: cron, state: 1, pid: 758
[28609.066339] task name: dbus-daemon, state: 1, pid: 760
[28609.066341] task name: NetworkManager, state: 1, pid: 761
[28609.066343] task name: irqbalance, state: 1, pid: 766
[28609.066346] task name: networkd-dispat, state: 1, pid: 767
[28609.066412] task name: polkitd, state: 1, pid: 769
[28609.066415] task name: rsyslogd, state: 1, pid: 771
[28609.066416] task name: snapd, state: 1, pid: 772
[28609.066417] task name: switcheroo-cont, state: 1, pid: 773
[28609.066418] task name: systemd-logind, state: 1, pid: 774
[28609.066420] task name: udisksd, state: 1, pid: 775
[28609.066421] task name: wpa_supplicant, state: 1, pid: 776
[28609.066422] task name: ModemManager, state: 1, pid: 868
[28609.066423] task name: unattended-upgr, state: 1, pid: 874
[28609.066424] task name: gdm3, state: 1, pid: 897
[28609.066426] task name: gdm-session-wor, state: 1, pid: 1436
[28609.066427] task name: gdm-x-session, state: 1, pid: 1509
[28609.066428] task name: Xorg, state: 0, pid: 1516
[28609.066429] task name: gnome-session-b, state: 1, pid: 1558
[28609.066431] task name: ssh-agent, state: 1, pid: 1625
[28609.066432] task name: whoopsie, state: 1, pid: 993
[28609.066433] task name: kerneloops, state: 1, pid: 994
[28609.066435] task name: kerneloops, state: 1, pid: 996
[28609.066436] task name: systemd-network, state: 1, pid: 1014
[28609.066438] task name: rtkit-daemon, state: 1, pid: 1056
[28609.076923] task name: irq/16-vmwgfx, state: 1, pid: 412
[28609.076923] task name: card0-crtc0, state: 1, pid: 413
[28609.076924] task name: card0-crtc1, state: 1, pid: 414
[28609.076925] task name: card0-crtc2, state: 1, pid: 415
[28609.076926] task name: card0-crtc3, state: 1, pid: 416
[28609.076926] task name: card0-crtc4, state: 1, pid: 417
[28609.076927] task name: card0-crtc5, state: 1, pid: 418
[28609.076928] task name: card0-crtc6, state: 1, pid: 419
[28609.076928] task name: card0-crtc7, state: 1, pid: 420
[28609.076929] task name: loop6, state: 1, pid: 422
[28609.076930] task name: loop7, state: 1, pid: 424
[28609.076931] task name: loop8, state: 1, pid: 429
[28609.076931] task name: loop9, state: 1, pid: 430
[28609.076932] task name: loop10, state: 1, pid: 436
[28609.076946] task name: loop11, state: 1, pid: 440
[28609.076947] task name: loop12, state: 1, pid: 441
[28609.076947] task name: cryptd, state: 1026, pid: 568
[28609.085952] task name: krfcomm, state: 1, pid: 1539
[28609.085957] task name: kworker/u257:2, state: 1026, pid: 6210
[28609.085959] task name: kworker/u257:0, state: 1026, pid: 8053
[28609.085961] task name: xfsalloc, state: 1026, pid: 15741
[28609.085962] task name: xfs_mru_cache, state: 1026, pid: 15742
[28609.085965] task name: jfsIO, state: 1, pid: 15746
[28609.085968] task name: jfsCommit, state: 1, pid: 15747
[28609.085970] task name: jfsCommit, state: 1, pid: 15748
[28609.085973] task name: jfsCommit, state: 1, pid: 15749
[28609.085975] task name: jfsCommit, state: 1, pid: 15750
[28609.085976] task name: jfsSync, state: 1, pid: 15751
[28609.085978] task name: kworker/1:0, state: 0, pid: 25533
[28609.085980] task name: kworker/u256:0, state: 1026, pid: 27945
[28609.085982] task name: kworker/3:3, state: 1026, pid: 28018
[28609.085984] task name: kworker/0:1, state: 1026, pid: 28095
[28609.085986] task name: kworker/2:1, state: 1026, pid: 28117
[28609.085988] task name: kworker/u256:1, state: 1026, pid: 28149
[28609.085989] task name: kworker/3:0, state: 1026, pid: 28163
[28609.085991] task name: kworker/0:2, state: 1026, pid: 28168
[28609.085992] task name: kworker/u256:2, state: 1026, pid: 28179
[28609.086101] task name: kworker/1:1, state: 1026, pid: 28208
[28609.086102] task name: kworker/2:2, state: 1026, pid: 28212
[28609.086105] task name: kworker/2:0, state: 1026, pid: 29449
[28609.086106] task name: kworker/u256:3, state: 1026, pid: 29463
[28609.086108] All of the current tasks are listed using a depth-first search(DFS) tree
[29924.024482] Goodbye
star@ubuntu:~/Desktop/dfsTree$
```