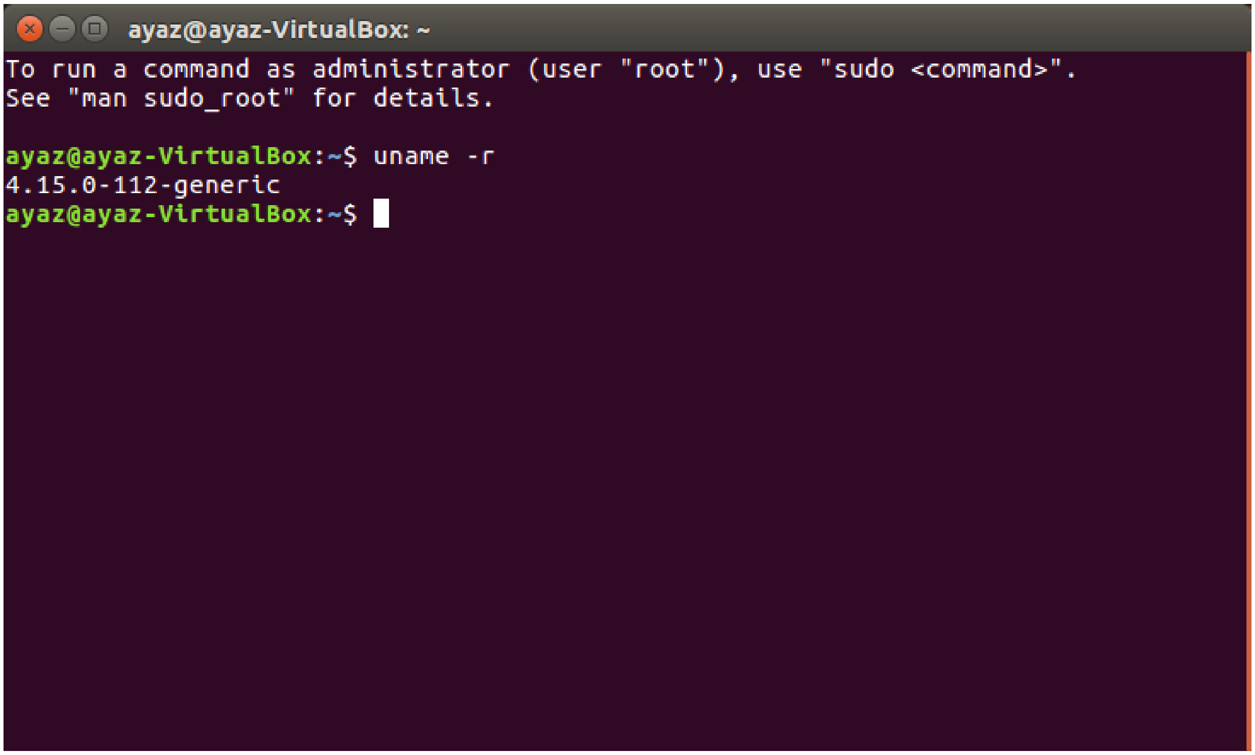
MUHAMMAD AYAZ HASAN
20K-1044
SE-5A

Kernel Assignment

Note:
Before Start.It is recommended to install ubuntu 16.04 and kernel version 4.19.261.Because it does not work for me on ubuntu 22.
Make sure to run all commands using "sudo".

1-

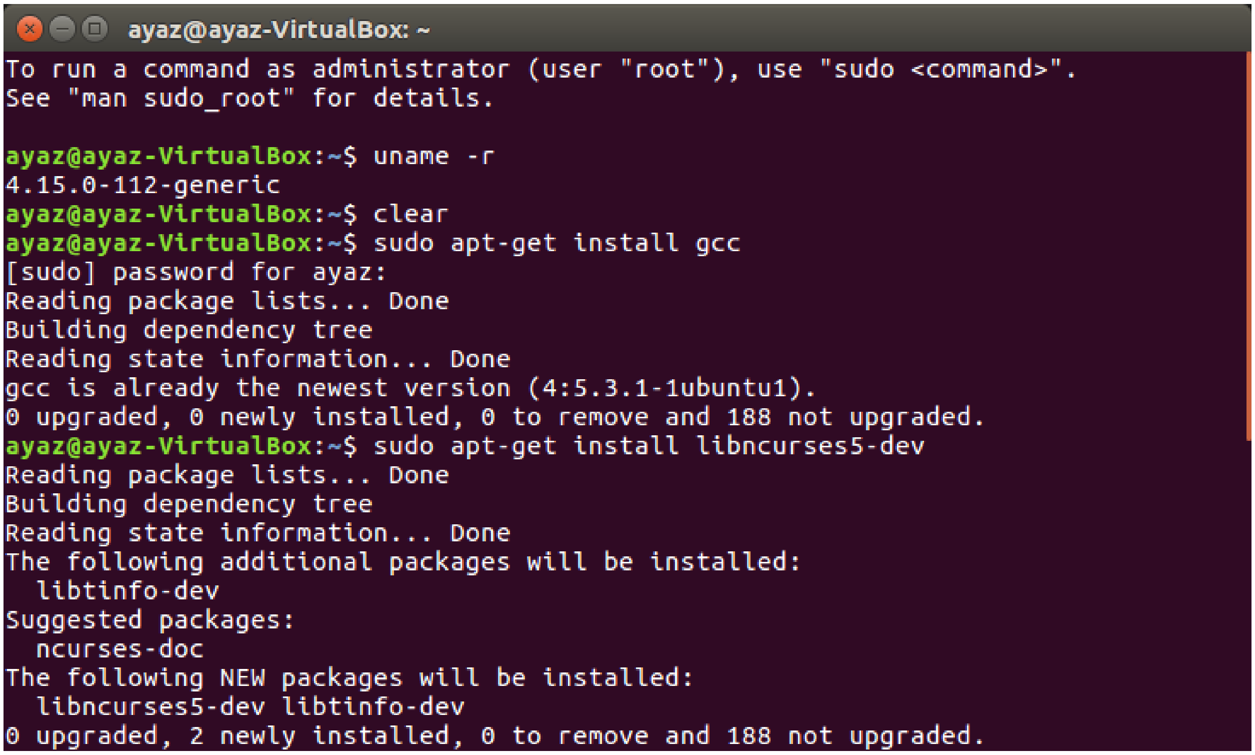
Check the current kernel version using the following command and download the next version from "kernel.org".



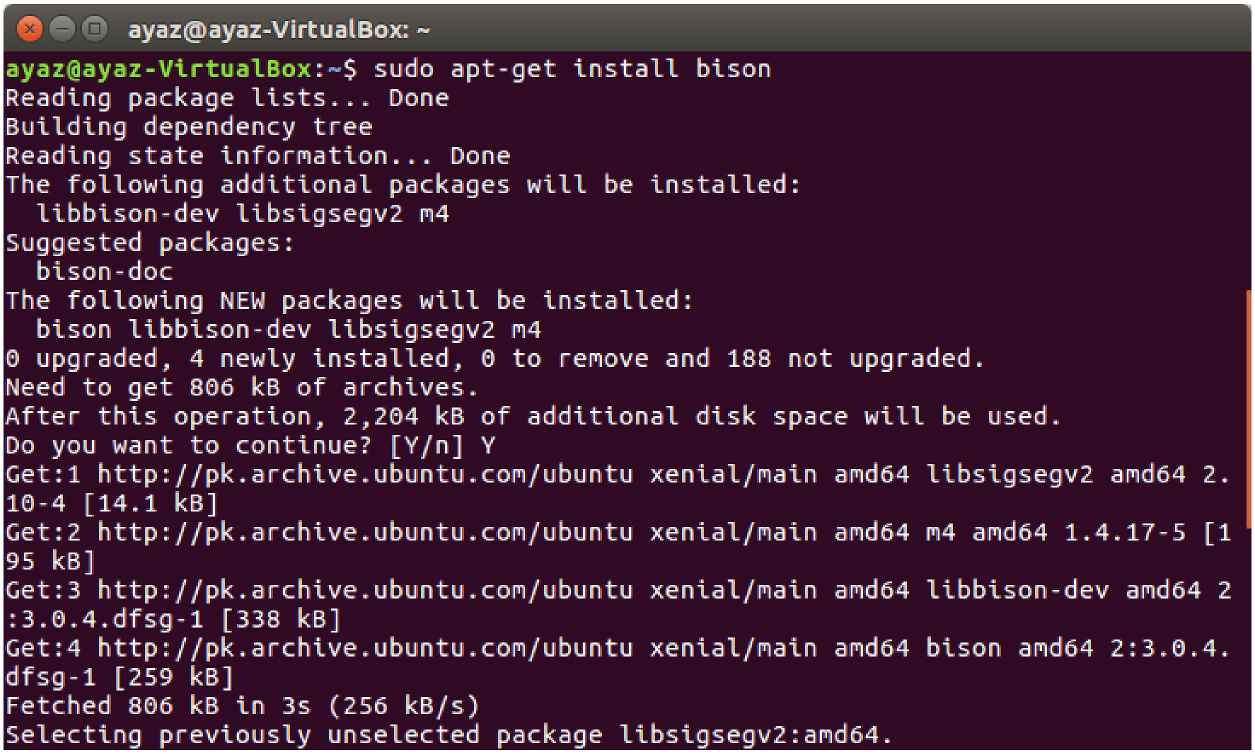
```
To run a command as administrator (user "root"), use "sudo <command>".
See "man sudo_root" for details.

ayaz@ayaz-VirtualBox:~$ uname -r
4.15.0-112-generic
ayaz@ayaz-VirtualBox:~$
```

2-

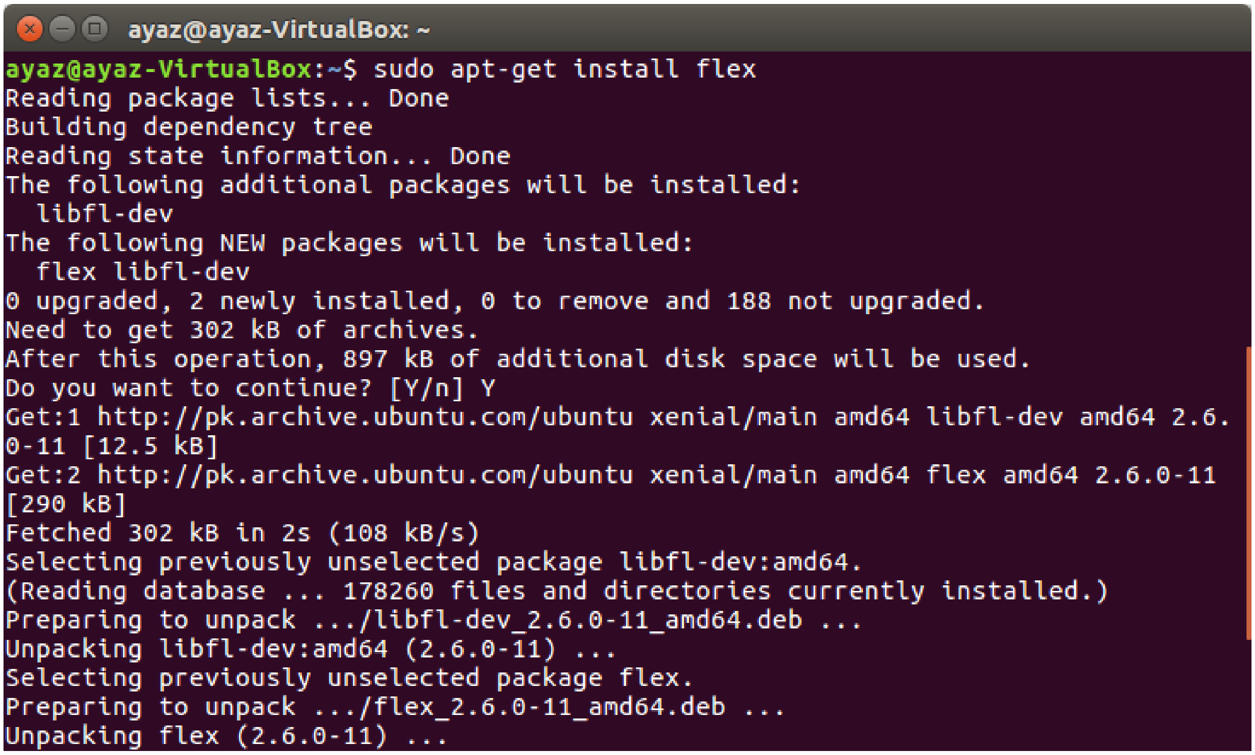
Install all these command



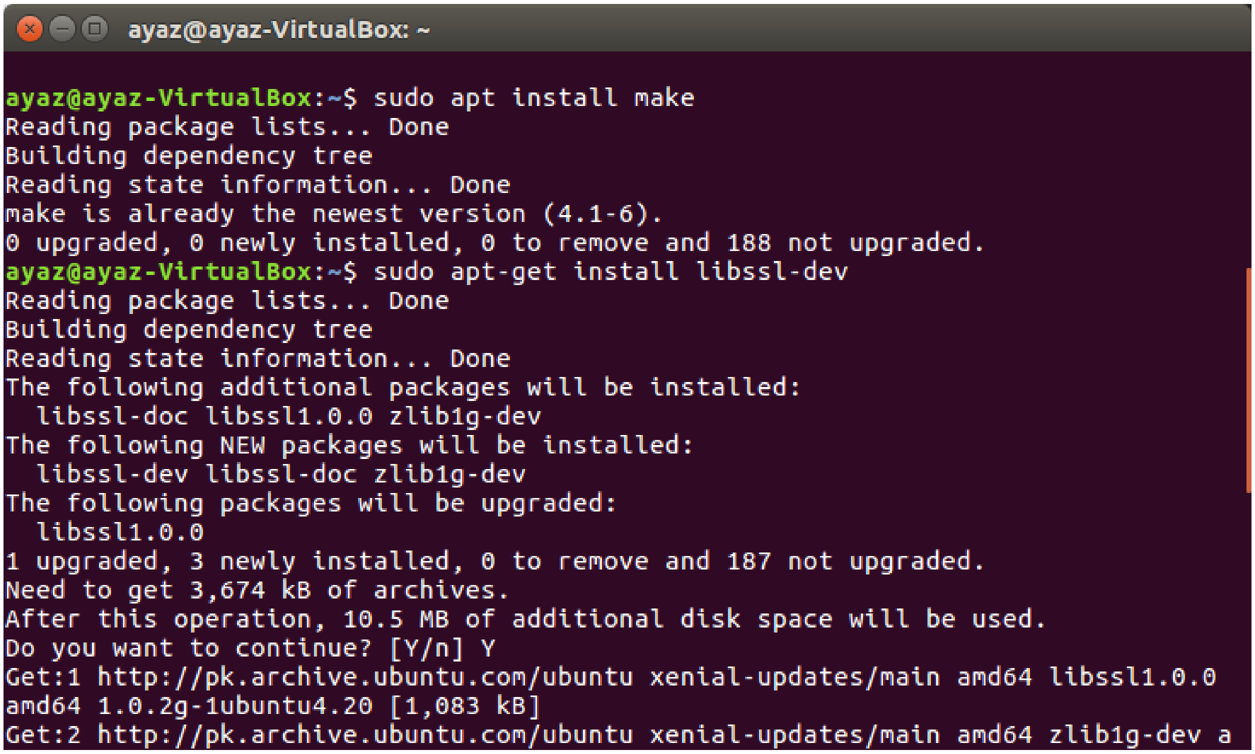
```
To run a command as administrator (user "root"), use "sudo <command>".
See "man sudo_root" for details.

ayaz@ayaz-VirtualBox:~$ uname -r
4.15.0-112-generic
ayaz@ayaz-VirtualBox:~$ clear
ayaz@ayaz-VirtualBox:~$ sudo apt-get install gcc
[sudo] password for ayaz:
Reading package lists... Done
Building dependency tree
Reading state information... Done
gcc is already the newest version (4:5.3.1-1ubuntu1).
0 upgraded, 0 newly installed, 0 to remove and 188 not upgraded.
ayaz@ayaz-VirtualBox:~$ sudo apt-get install libncurses5-dev
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  libtinfo-dev
Suggested packages:
  ncurses-doc
The following NEW packages will be installed:
  libncurses5-dev libtinfo-dev
0 upgraded, 2 newly installed, 0 to remove and 188 not upgraded.
```



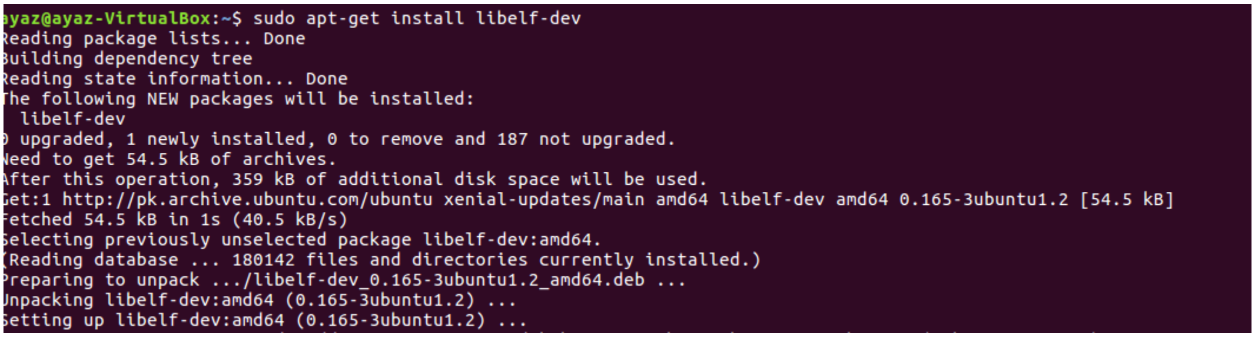
```
ayaz@ayaz-VirtualBox:~$ sudo apt-get install bison
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  libbison-dev libsigsegv2 m4
Suggested packages:
  bison-doc
The following NEW packages will be installed:
  bison libbison-dev libsigsegv2 m4
0 upgraded, 4 newly installed, 0 to remove and 188 not upgraded.
Need to get 806 kB of archives.
After this operation, 2,204 kB of additional disk space will be used.
Do you want to continue? [Y/n] Y
Get:1 http://pk.archive.ubuntu.com/ubuntu xenial/main amd64 libsigsegv2 amd64 2.
10-4 [14.1 kB]
Get:2 http://pk.archive.ubuntu.com/ubuntu xenial/main amd64 m4 amd64 1.4.17-5 [1
95 kB]
Get:3 http://pk.archive.ubuntu.com/ubuntu xenial/main amd64 libbison-dev amd64 2
:3.0.4.dfsg-1 [338 kB]
Get:4 http://pk.archive.ubuntu.com/ubuntu xenial/main amd64 bison amd64 2:3.0.4.
dfsg-1 [259 kB]
Fetched 806 kB in 3s (256 kB/s)
Selecting previously unselected package libsigsegv2:amd64.
```



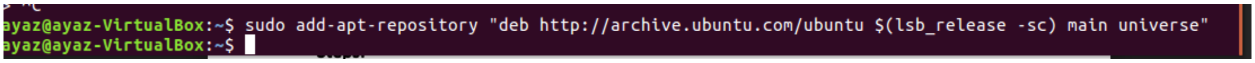
```
ayaz@ayaz-VirtualBox:~$ sudo apt-get install flex
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  libfl-dev
The following NEW packages will be installed:
  flex libfl-dev
0 upgraded, 2 newly installed, 0 to remove and 188 not upgraded.
Need to get 302 kB of archives.
After this operation, 897 kB of additional disk space will be used.
Do you want to continue? [Y/n] Y
Get:1 http://pk.archive.ubuntu.com/ubuntu xenial/main amd64 libfl-dev amd64 2.6.
0-11 [12.5 kB]
Get:2 http://pk.archive.ubuntu.com/ubuntu xenial/main amd64 flex amd64 2.6.0-11
[290 kB]
Fetched 302 kB in 2s (108 kB/s)
Selecting previously unselected package libfl-dev:amd64.
(Reading database ... 178260 files and directories currently installed.)
Preparing to unpack .../libfl-dev_2.6.0-11_amd64.deb ...
Unpacking libfl-dev:amd64 (2.6.0-11) ...
Selecting previously unselected package flex.
Preparing to unpack .../flex_2.6.0-11_amd64.deb ...
Unpacking flex (2.6.0-11) ...
```



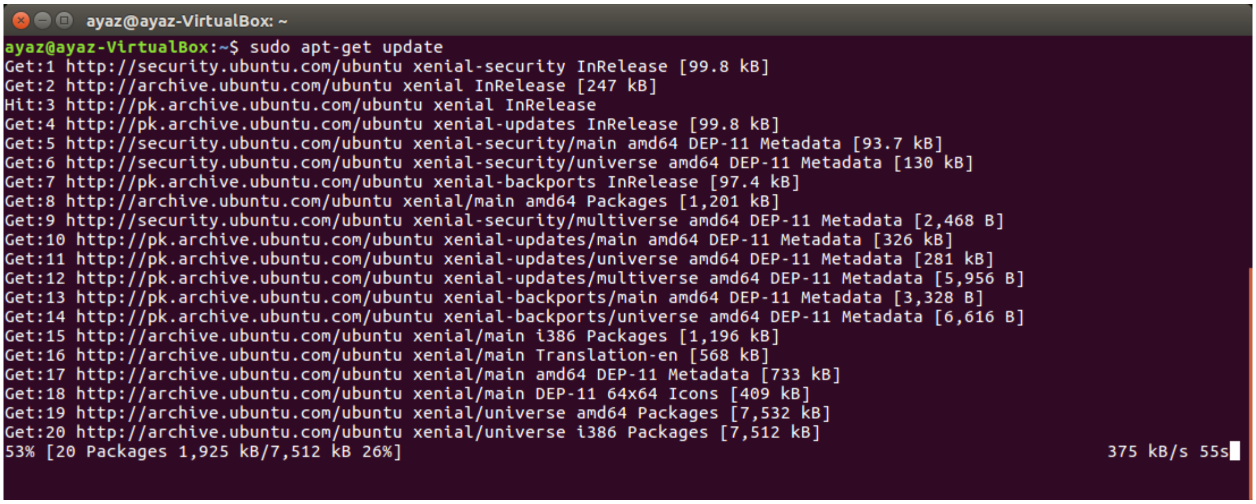
```
ayaz@ayaz-VirtualBox:~$ sudo apt install make
Reading package lists... Done
Building dependency tree
Reading state information... Done
make is already the newest version (4.1-6).
0 upgraded, 0 newly installed, 0 to remove and 188 not upgraded.
ayaz@ayaz-VirtualBox:~$ sudo apt-get install libssl-dev
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  libssl-doc libssl1.0.0 zlib1g-dev
The following NEW packages will be installed:
  libssl-dev libssl-doc zlib1g-dev
The following packages will be upgraded:
  libssl1.0.0
1 upgraded, 3 newly installed, 0 to remove and 187 not upgraded.
Need to get 3,674 kB of archives.
After this operation, 10.5 MB of additional disk space will be used.
Do you want to continue? [Y/n] Y
Get:1 http://pk.archive.ubuntu.com/ubuntu xenial-updates/main amd64 libssl1.0.0
amd64 1.0.2g-1ubuntu4.20 [1,083 kB]
Get:2 http://pk.archive.ubuntu.com/ubuntu xenial-updates/main amd64 zlib1g-dev a
```



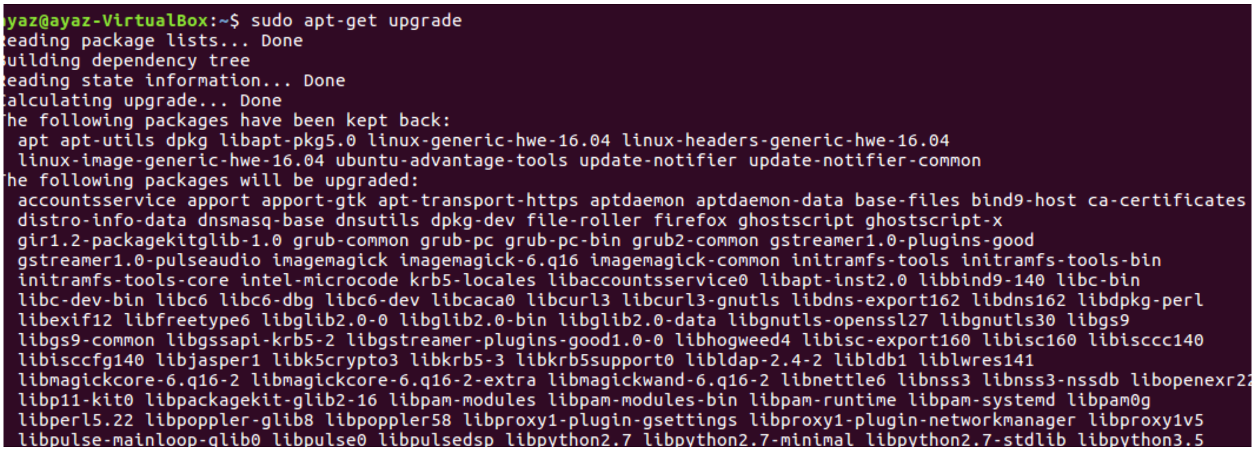
```
ayaz@ayaz-VirtualBox:~$ sudo apt-get install libelf-dev
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following NEW packages will be installed:
  libelf-dev
0 upgraded, 1 newly installed, 0 to remove and 187 not upgraded.
Need to get 54.5 kB of archives.
After this operation, 359 kB of additional disk space will be used.
Get:1 http://pk.archive.ubuntu.com/ubuntu xenial-updates/main amd64 libelf-dev amd64 0.165-3ubuntu1.2 [54.5 kB]
Fetched 54.5 kB in 1s (40.5 kB/s)
Selecting previously unselected package libelf-dev:amd64.
(Reading database ... 180142 files and directories currently installed.)
Preparing to unpack .../libelf-dev_0.165-3ubuntu1.2_amd64.deb ...
Unpacking libelf-dev:amd64 (0.165-3ubuntu1.2) ...
Setting up libelf-dev:amd64 (0.165-3ubuntu1.2) ...
```



```
ayaz@ayaz-VirtualBox:~$ sudo add-apt-repository "deb http://archive.ubuntu.com/ubuntu $(lsb_release -sc) main universe"
ayaz@ayaz-VirtualBox:~$
```



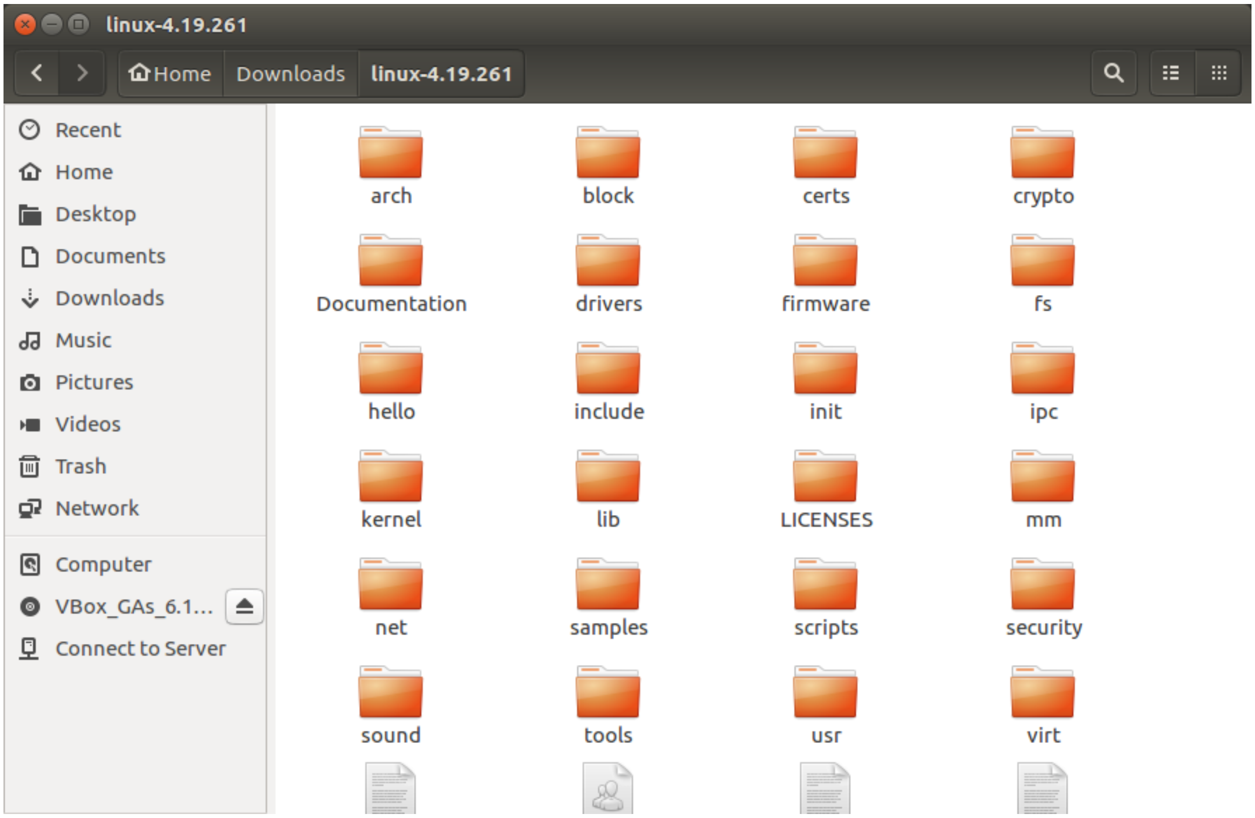
```
ayaz@ayaz-VirtualBox:~$ sudo apt-get update
Get:1 http://security.ubuntu.com/ubuntu xenial-security InRelease [99.8 kB]
Get:2 http://archive.ubuntu.com/ubuntu xenial InRelease [247 kB]
Hit:3 http://pk.archive.ubuntu.com/ubuntu xenial InRelease
Get:4 http://pk.archive.ubuntu.com/ubuntu xenial-updates InRelease [99.8 kB]
Get:5 http://security.ubuntu.com/ubuntu xenial-security/main amd64 DEP-11 Metadata [93.7 kB]
Get:6 http://security.ubuntu.com/ubuntu xenial-security/universe amd64 DEP-11 Metadata [130 kB]
Get:7 http://pk.archive.ubuntu.com/ubuntu xenial-backports InRelease [97.4 kB]
Get:8 http://archive.ubuntu.com/ubuntu xenial/main amd64 Packages [1,201 kB]
Get:9 http://security.ubuntu.com/ubuntu xenial-security/multiverse amd64 DEP-11 Metadata [2,468 B]
Get:10 http://pk.archive.ubuntu.com/ubuntu xenial-updates/main amd64 DEP-11 Metadata [326 kB]
Get:11 http://pk.archive.ubuntu.com/ubuntu xenial-updates/universe amd64 DEP-11 Metadata [281 kB]
Get:12 http://pk.archive.ubuntu.com/ubuntu xenial-updates/multiverse amd64 DEP-11 Metadata [5,956 B]
Get:13 http://pk.archive.ubuntu.com/ubuntu xenial-backports/main amd64 DEP-11 Metadata [3,328 B]
Get:14 http://pk.archive.ubuntu.com/ubuntu xenial-backports/universe amd64 DEP-11 Metadata [6,616 B]
Get:15 http://archive.ubuntu.com/ubuntu xenial/main i386 Packages [1,196 kB]
Get:16 http://archive.ubuntu.com/ubuntu xenial/main Translation-en [568 kB]
Get:17 http://archive.ubuntu.com/ubuntu xenial/main amd64 DEP-11 Metadata [733 kB]
Get:18 http://archive.ubuntu.com/ubuntu xenial/main DEP-11 64x64 Icons [409 kB]
Get:19 http://archive.ubuntu.com/ubuntu xenial/universe amd64 Packages [7,532 kB]
Get:20 http://archive.ubuntu.com/ubuntu xenial/universe i386 Packages [7,512 kB]
53% [20 Packages 1,925 kB/7,512 kB 26%]                                                      375 kB/s 55s
```



```
yaz@ayaz-VirtualBox:~$ sudo apt-get upgrade
eading package lists... Done
uilding dependency tree
eading state information... Done
alculating upgrade... Done
he following packages have been kept back:
 apt apt-utils dpkg libapt-pkg5.0 linux-generic-hwe-16.04 linux-headers-generic-hwe-16.04
 linux-image-generic-hwe-16.04 ubuntu-advantage-tools update-notifier update-notifier-common
he following packages will be upgraded:
 accountsservice apport apport-gtk apt-transport-https aptdaemon aptdaemon-data base-files bind9-host ca-certificates
 distro-info-data dnsmasq-base dnsutils dpkg-dev file-roller firefox ghostscript ghostscript-x
 gir1.2-packagekitglib-1.0 grub-common grub-pc grub-pc-bin grub2-common gstreamer1.0-plugins-good
 gstreamer1.0-pulseaudio imagemagick imagemagick-6.q16 imagemagick-common initramfs-tools initramfs-tools-bin
 initramfs-tools-core intel-microcode krb5-locales libaccountsservice0 libapt-inst2.0 libbind9-140 libc-bin
 libc-dev-bin libc6 libc6-dbg libc6-dev libcaca0 libcurl3 libcurl3-gnutls libdns-export162 libdns162 libdpkg-perl
 libexif12 libfreetype6 libglib2.0-0 libglib2.0-bin libglib2.0-data libgnutls-openssl27 libgnutls30 libgs9
 libgs9-common libgssapi-krb5-2 libgstreamer-plugins-good1.0-0 libhogweed4 libisc-export160 libisc160 libisccc140
 libisccfg140 libjasper1 libk5crypto3 libkrb5-3 libkrb5support0 libldap-2.4-2 libldb1 liblwres141
 libmagickcore-6.q16-2 libmagickcore-6.q16-2-extra libmagickwand-6.q16-2 libnettle6 libnss3 libnss3-nssdb libopenexr22
 libp11-kit0 libpackagekit-glib2-16 libpam-modules libpam-modules-bin libpam-runtime libpam-systemd libpam0g
 libperl5.22 libpoppler-glib8 libpoppler58 libproxy1-plugin-gsettings libproxy1-plugin-networkmanager libproxy1v5
 libpulse-mainloop-glib0 libpulse0 libpulsedsp libpython2.7 libpython2.7-minimal libpython2.7-stdlib libpython3.5
```

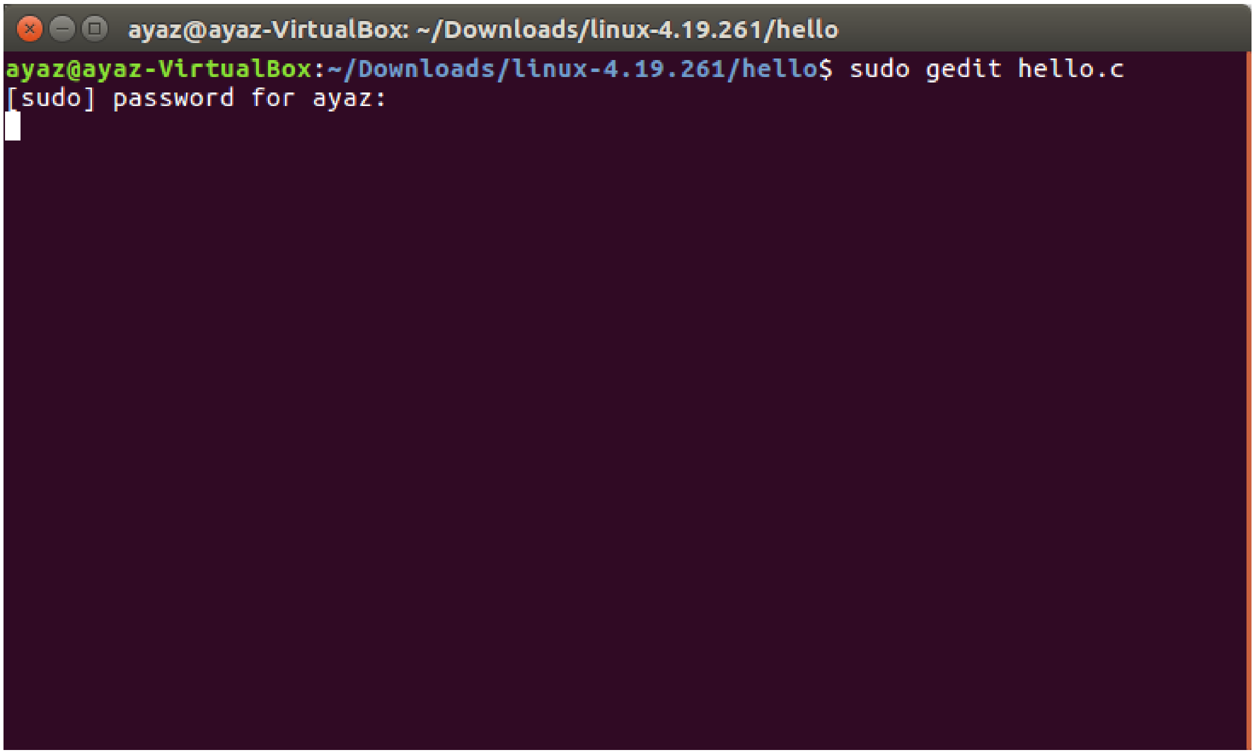
3-

In the downloaded file of linux create a file with name “hello” and open this folder in terminal.



4-

Now it will set the path to hello.



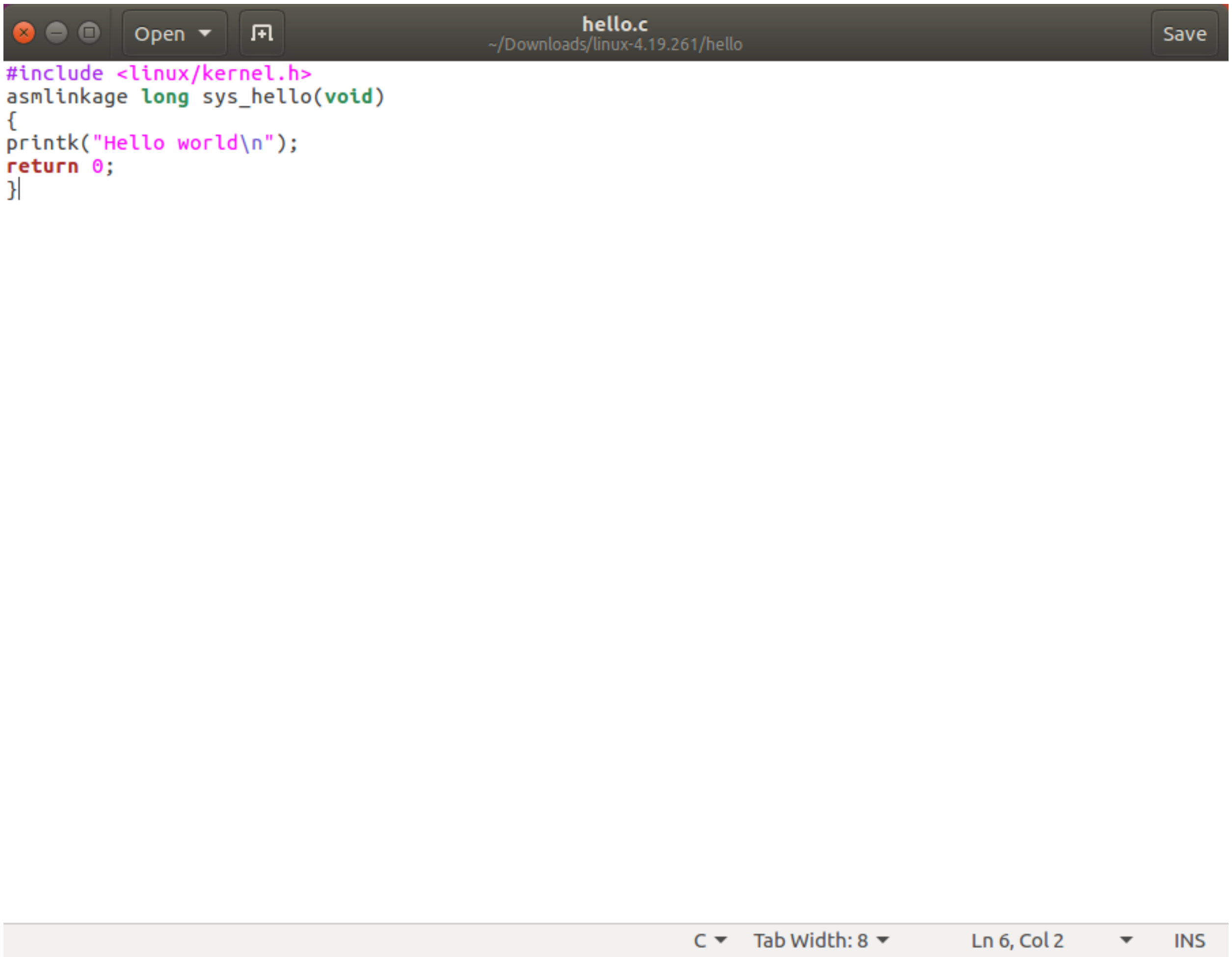
```
ayaz@ayaz-VirtualBox:~/Downloads/linux-4.19.261/hello$ sudo gedit hello.c
[sudo] password for ayaz:
```

5-
Now use the command “sudo gedit hello.c” and open a file in the text editor.
Now include the following code in this file.

```
#include <linux/kernel.h>
asmlinkage long sys_hello(void)
{
printk("Hello world\n");
return 0;
}
```

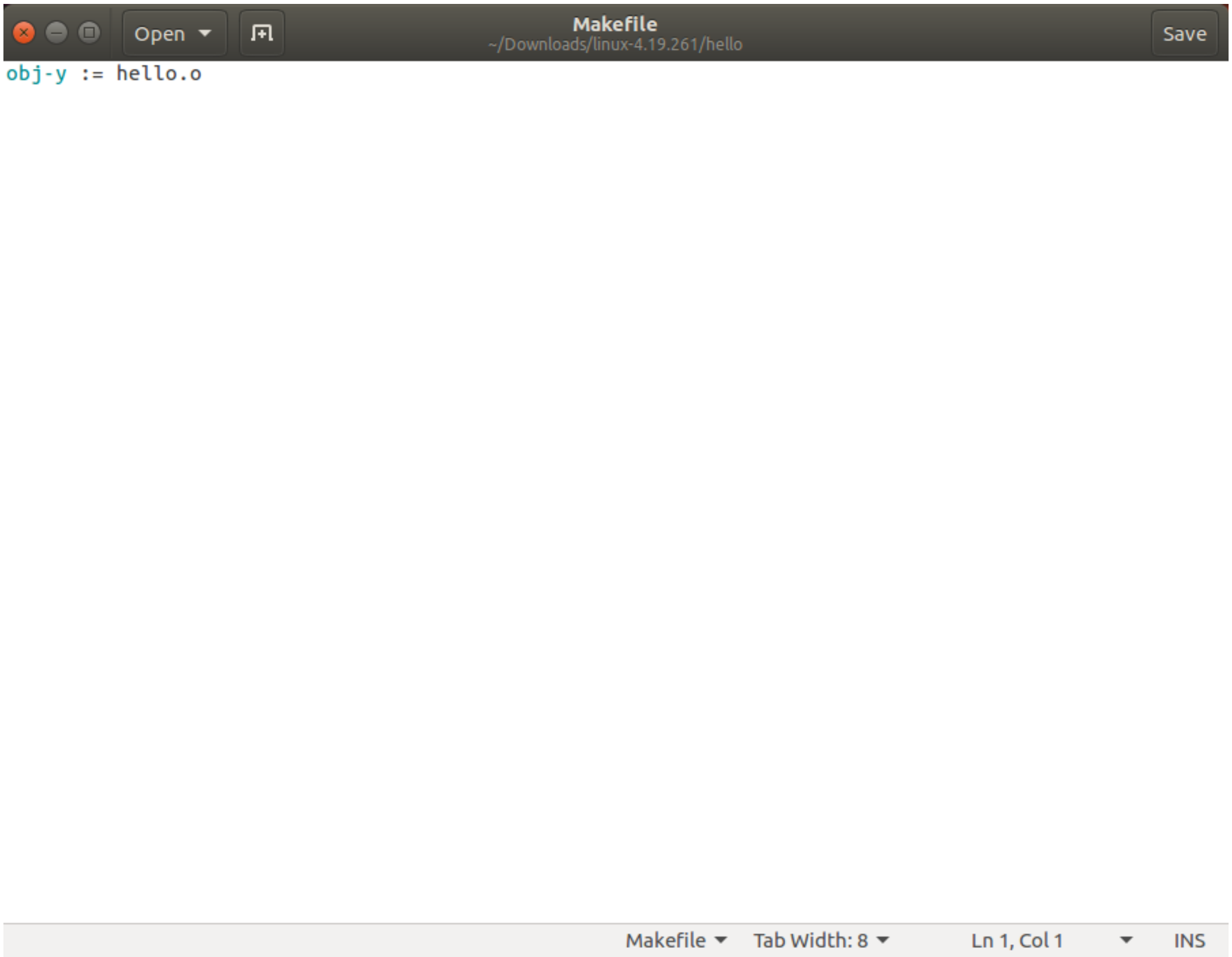
Code detail:

- The above library is used to build a system call for kernel
- Asmlinkage take the argument and store it on a stack instead of register
- “Printk” will print it on the kernel log
- If this program returns 0 on running means it will successfully written “Hello World” to the kernel.



```c
#include <linux/kernel.h>
asmlinkage long sys_hello(void)
{
printk("Hello world\n");
return 0;
}
```

6-
Now using this command on terminal “gedit Makefile” and in the text editor write the following line “obj-y := hello.o”.



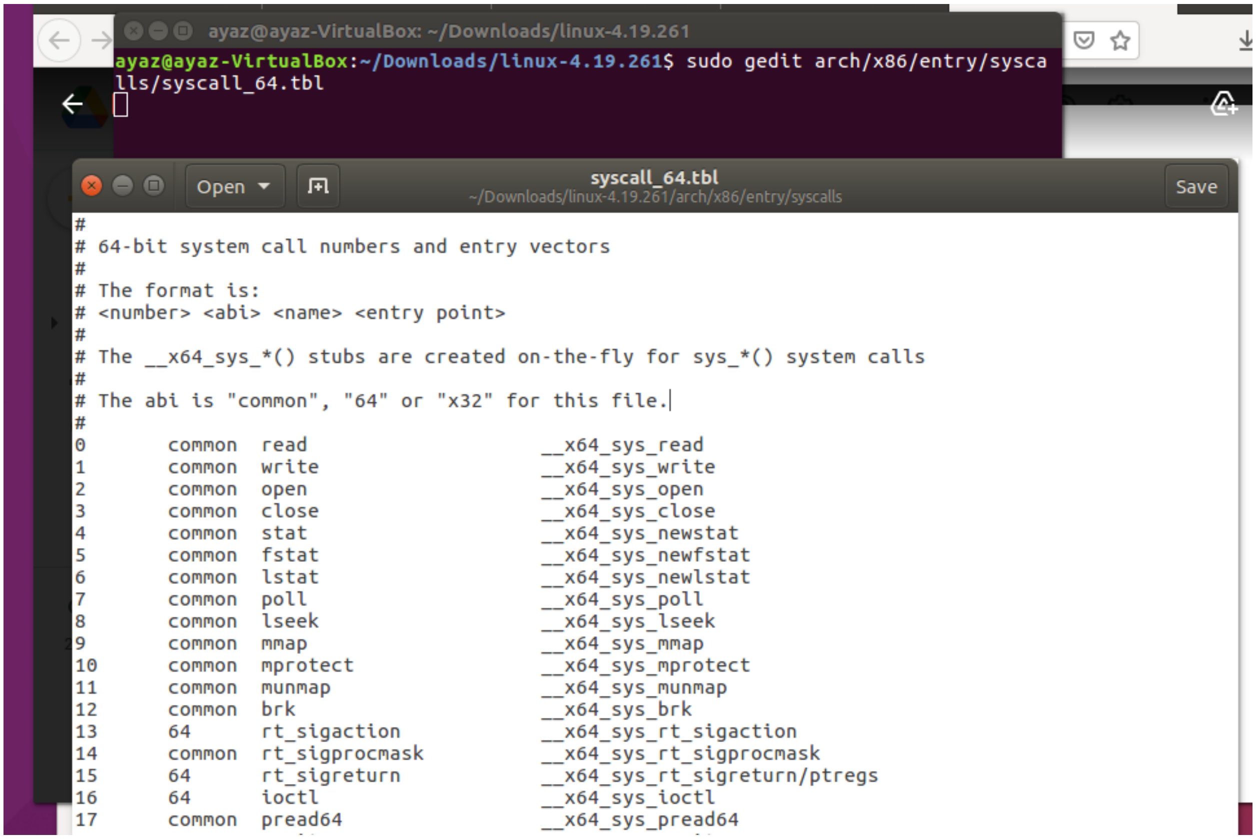
Open
Makefile
~/Downloads/linux-4.19.261/hello
Save

```
obj-y := hello.o
```

Makefile
Tab Width: 8
Ln 1, Col 1
INS

7-

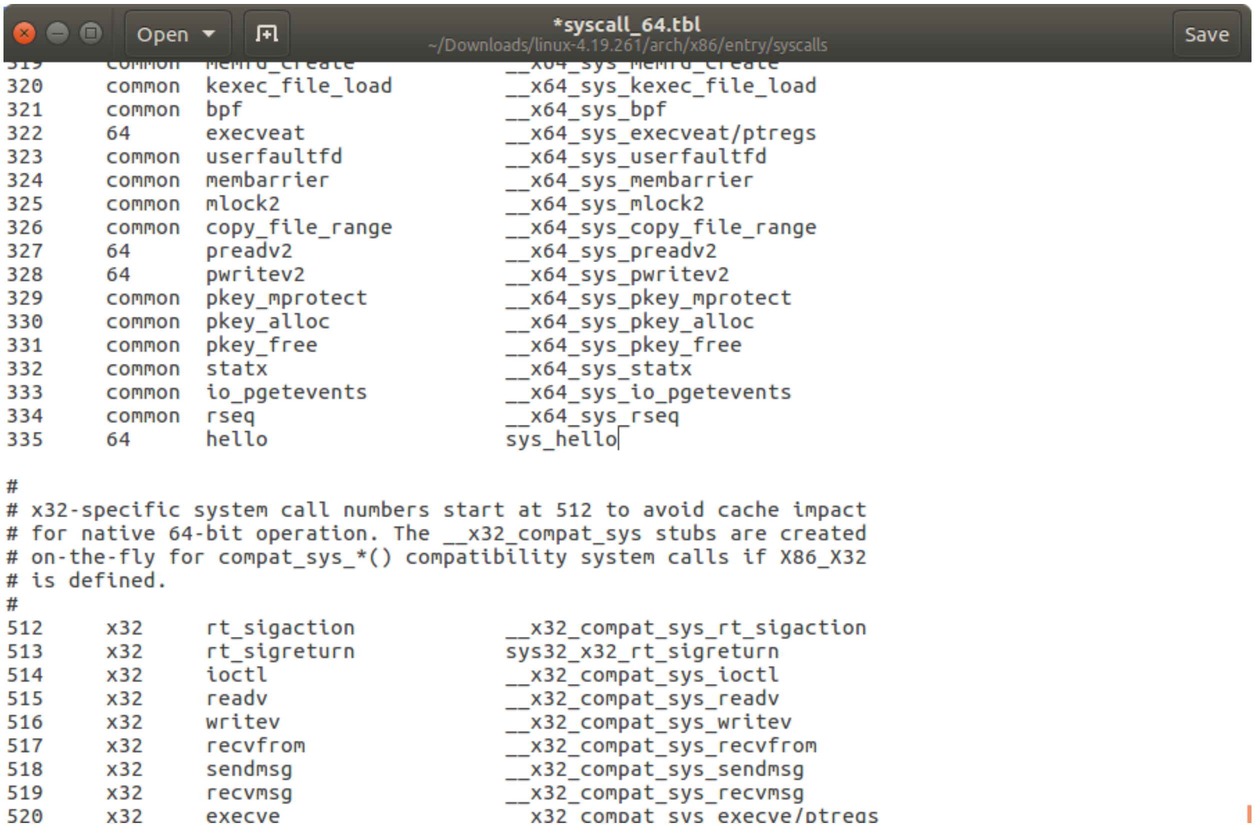
Now use the following command on terminal that shown below (we use syscall_64 because we create system call on 64 bit).


ayaz@ayaz-VirtualBox: ~/Downloads/linux-4.19.261
Open
syscall_64.tbl
~/Downloads/linux-4.19.261/arch/x86/entry/syscalls
Save

```
ayaz@ayaz-VirtualBox:~/Downloads/linux-4.19.261$ sudo gedit arch/x86/entry/sysca
lls/syscall_64.tbl
```

```
#
# 64-bit system call numbers and entry vectors
#
# The format is:
# <number> <abi> <name> <entry point>
#
# The __x64_sys_*() stubs are created on-the-fly for sys_*() system calls
#
# The abi is "common", "64" or "x32" for this file.
#
0       common  read                    __x64_sys_read
1       common  write                   __x64_sys_write
2       common  open                    __x64_sys_open
3       common  close                   __x64_sys_close
4       common  stat                    __x64_sys_newstat
5       common  fstat                   __x64_sys_newfstat
6       common  lstat                   __x64_sys_newlstat
7       common  poll                    __x64_sys_poll
8       common  lseek                   __x64_sys_lseek
9       common  mmap                    __x64_sys_mmap
10      common  mprotect                __x64_sys_mprotect
11      common  munmap                  __x64_sys_munmap
12      common  brk                     __x64_sys_brk
13      64      rt_sigaction            __x64_sys_rt_sigaction
14      common  rt_sigprocmask          __x64_sys_rt_sigprocmask
15      64      rt_sigreturn            __x64_sys_rt_sigreturn/ptregs
16      64      ioctl                   __x64_sys_ioctl
17      common  pread64                 __x64_sys_pread64
```

In this file after line #334 add the new line which is line 335 and the below line that shown in fig:

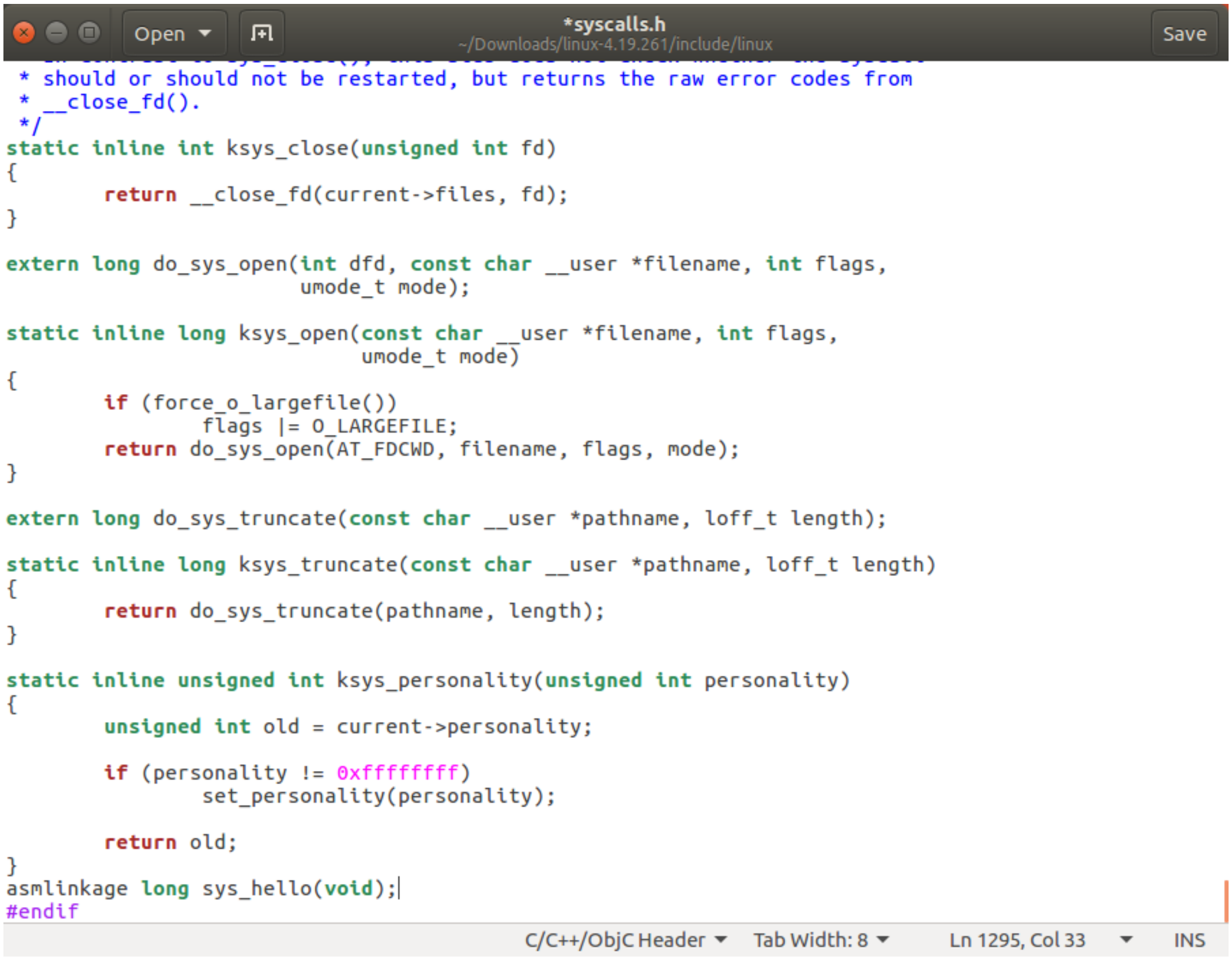


```
319     common  memfd_create            __x64_sys_memfd_create
320     common  kexec_file_load         __x64_sys_kexec_file_load
321     common  bpf                     __x64_sys_bpf
322     64      execveat                __x64_sys_execveat/ptregs
323     common  userfaultfd             __x64_sys_userfaultfd
324     common  membarrier              __x64_sys_membarrier
325     common  mlock2                  __x64_sys_mlock2
326     common  copy_file_range         __x64_sys_copy_file_range
327     64      preadv2                 __x64_sys_preadv2
328     64      pwritev2                __x64_sys_pwritev2
329     common  pkey_mprotect           __x64_sys_pkey_mprotect
330     common  pkey_alloc              __x64_sys_pkey_alloc
331     common  pkey_free               __x64_sys_pkey_free
332     common  statx                   __x64_sys_statx
333     common  io_pgetevents           __x64_sys_io_pgetevents
334     common  rseq                    __x64_sys_rseq
335     64      hello                   sys_hello

#
# x32-specific system call numbers start at 512 to avoid cache impact
# for native 64-bit operation. The __x32_compat_sys stubs are created
# on-the-fly for compat_sys_*() compatibility system calls if X86_X32
# is defined.
#
512     x32     rt_sigaction            __x32_compat_sys_rt_sigaction
513     x32     rt_sigreturn            sys32_x32_rt_sigreturn
514     x32     ioctl                   __x32_compat_sys_ioctl
515     x32     readv                   __x32_compat_sys_readv
516     x32     writev                  __x32_compat_sys_writev
517     x32     recvfrom                __x32_compat_sys_recvfrom
518     x32     sendmsg                 __x32_compat_sys_sendmsg
519     x32     recvmsg                 __x32_compat_sys_recvmsg
520     x32     execve                  __x32_compat_sys_execve/ptregs
```

8-

Now using the command “include/linux/syscalls.h”

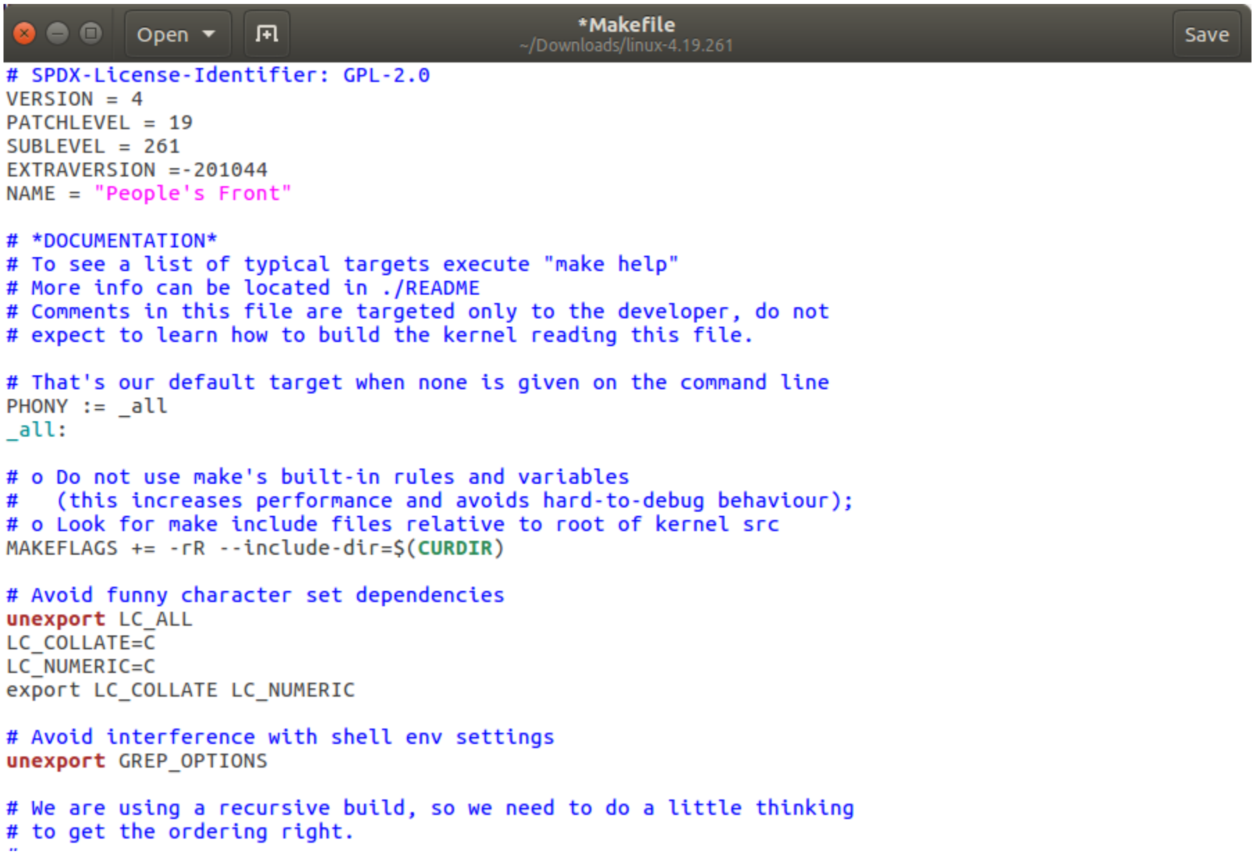
And add “asmlinkage long sys_hello(void)” in this file which we write in hello.c file.



```
 * should or should not be restarted, but returns the raw error codes from
 * __close_fd().
 */
static inline int ksys_close(unsigned int fd)
{
        return __close_fd(current->files, fd);
}

extern long do_sys_open(int dfd, const char __user *filename, int flags,
                        umode_t mode);

static inline long ksys_open(const char __user *filename, int flags,
                             umode_t mode)
{
        if (force_o_largefile())
                flags |= O_LARGEFILE;
        return do_sys_open(AT_FDCWD, filename, flags, mode);
}

extern long do_sys_truncate(const char __user *pathname, loff_t length);

static inline long ksys_truncate(const char __user *pathname, loff_t length)
{
        return do_sys_truncate(pathname, length);
}

static inline unsigned int ksys_personality(unsigned int personality)
{
        unsigned int old = current->personality;

        if (personality != 0xffffffff)
                set_personality(personality);

        return old;
}
asmlinkage long sys_hello(void);
#endif
```

9-

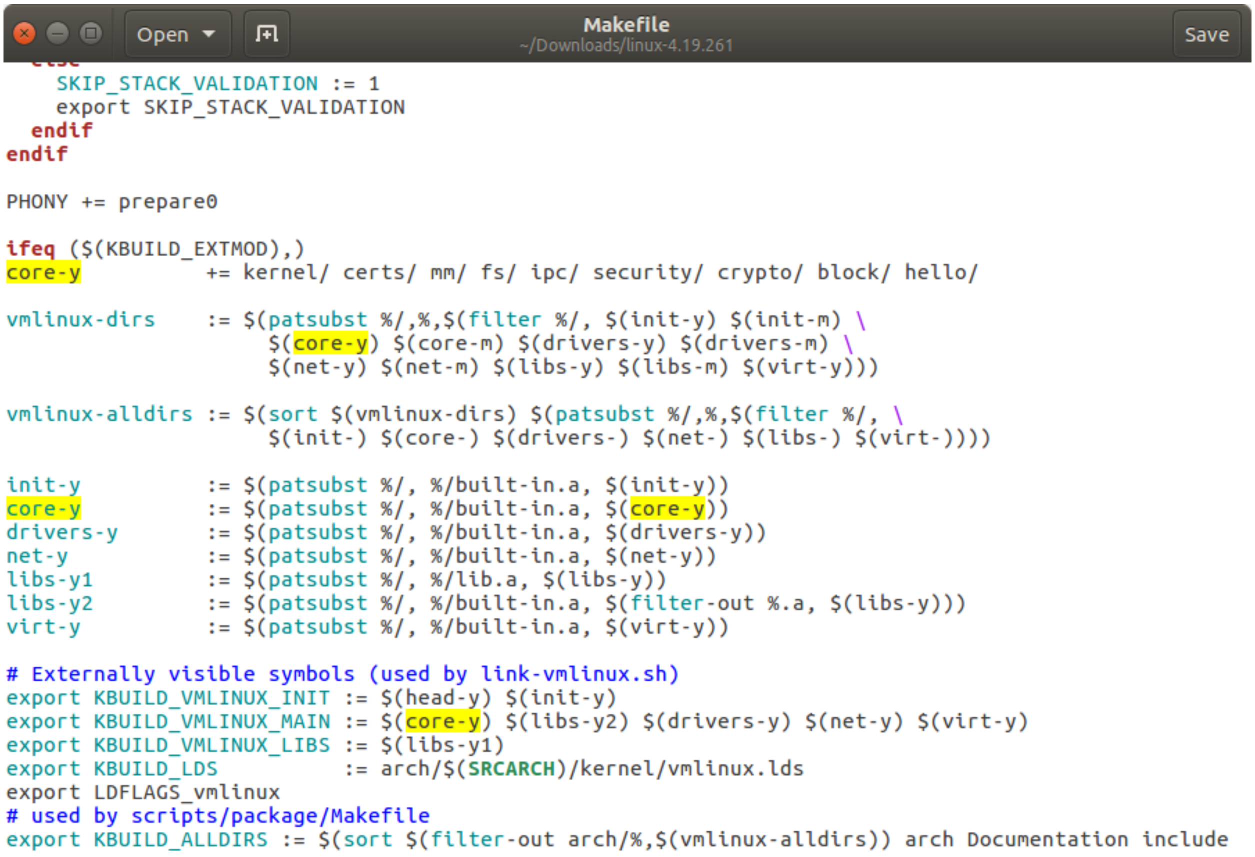
Now open the kernel's file with the name “Makefile” and in EXTRAVERSION add your roll no like in this format “-201044” .



```
# SPDX-License-Identifier: GPL-2.0
VERSION = 4
PATCHLEVEL = 19
SUBLEVEL = 261
EXTRAVERSION =-201044
NAME = "People's Front"

# *DOCUMENTATION*
# To see a list of typical targets execute "make help"
# More info can be located in ./README
# Comments in this file are targeted only to the developer, do not
# expect to learn how to build the kernel reading this file.

# That's our default target when none is given on the command line
PHONY := _all
_all:

# o Do not use make's built-in rules and variables
#   (this increases performance and avoids hard-to-debug behaviour);
# o Look for make include files relative to root of kernel src
MAKEFLAGS += -rR --include-dir=$(CURDIR)

# Avoid funny character set dependencies
unexport LC_ALL
LC_COLLATE=C
LC_NUMERIC=C
export LC_COLLATE LC_NUMERIC

# Avoid interference with shell env settings
unexport GREP_OPTIONS

# We are using a recursive build, so we need to do a little thinking
# to get the ordering right.
```

10-

Now press ctrl+F and search core-y and add new module “ hello/ “ after block/
(make sure to give space after block/)

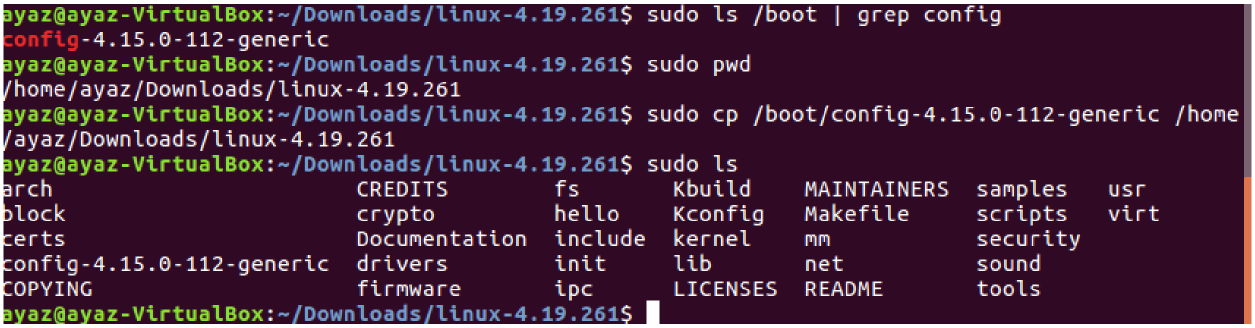


```
    SKIP_STACK_VALIDATION := 1
    export SKIP_STACK_VALIDATION
  endif
endif

PHONY += prepare0

ifeq ($(KBUILD_EXTMOD),)
core-y          += kernel/ certs/ mm/ fs/ ipc/ security/ crypto/ block/ hello/

vmlinux-dirs    := $(patsubst %/,%,$(filter %/, $(init-y) $(init-m) \
                     $(core-y) $(core-m) $(drivers-y) $(drivers-m) \
                     $(net-y) $(net-m) $(libs-y) $(libs-m) $(virt-y)))

vmlinux-alldirs := $(sort $(vmlinux-dirs) $(patsubst %/,%,$(filter %/, \
                     $(init-) $(core-) $(drivers-) $(net-) $(libs-) $(virt-))))

init-y          := $(patsubst %/, %/built-in.a, $(init-y))
core-y          := $(patsubst %/, %/built-in.a, $(core-y))
drivers-y       := $(patsubst %/, %/built-in.a, $(drivers-y))
net-y           := $(patsubst %/, %/built-in.a, $(net-y))
libs-y1         := $(patsubst %/, %/lib.a, $(libs-y))
libs-y2         := $(patsubst %/, %/built-in.a, $(filter-out %.a, $(libs-y)))
virt-y          := $(patsubst %/, %/built-in.a, $(virt-y))

# Externally visible symbols (used by link-vmlinux.sh)
export KBUILD_VMLINUX_INIT := $(head-y) $(init-y)
export KBUILD_VMLINUX_MAIN := $(core-y) $(libs-y2) $(drivers-y) $(net-y) $(virt-y)
export KBUILD_VMLINUX_LIBS := $(libs-y1)
export KBUILD_LDS          := arch/$(SRCARCH)/kernel/vmlinux.lds
export LDFLAGS_vmlinux
# used by scripts/package/Makefile
export KBUILD_ALLDIRS := $(sort $(filter-out arch/%,$(vmlinux-alldirs)) arch Documentation include
```

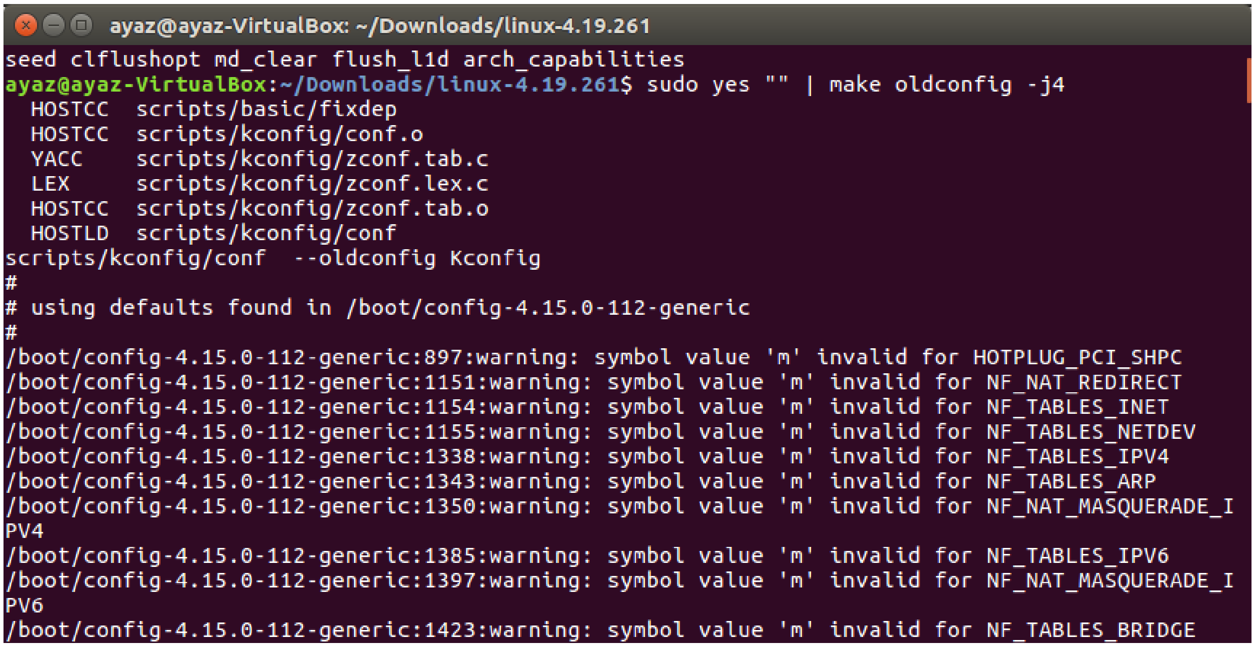
11-

Now run the following command in sequence

- “sudo ls/boot | grep config (it will show the oldconfig)
- “sudo pwd” it will set to the present directory
- Now copy the config and add this next command which is “sudo cp /boot/config-4.15.0-112-generic /home/ayaz/Downloads/linux-4.19.261
- Now using command “sudo ls” check weather the config is present or not if it is then go ahead.
- Now using the command “yes “” | make oldconfig -j4” it will create a new configuration .



```
ayaz@ayaz-VirtualBox:~/Downloads/linux-4.19.261$ sudo ls /boot | grep config
config-4.15.0-112-generic
ayaz@ayaz-VirtualBox:~/Downloads/linux-4.19.261$ sudo pwd
/home/ayaz/Downloads/linux-4.19.261
ayaz@ayaz-VirtualBox:~/Downloads/linux-4.19.261$ sudo cp /boot/config-4.15.0-112-generic /home
/ayaz/Downloads/linux-4.19.261
ayaz@ayaz-VirtualBox:~/Downloads/linux-4.19.261$ sudo ls
arch                       CREDITS        fs       Kbuild    MAINTAINERS  samples   usr
block                      crypto         hello    Kconfig   Makefile     scripts   virt
certs                      Documentation  include  kernel    mm           security
config-4.15.0-112-generic  drivers        init     lib       net          sound
COPYING                    firmware       ipc      LICENSES  README       tools
ayaz@ayaz-VirtualBox:~/Downloads/linux-4.19.261$
```

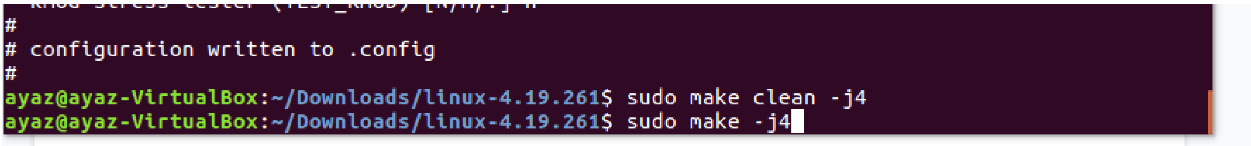


```
seed clflushopt md_clear flush_l1d arch_capabilities
ayaz@ayaz-VirtualBox:~/Downloads/linux-4.19.261$ sudo yes "" | make oldconfig -j4
  HOSTCC  scripts/basic/fixdep
  HOSTCC  scripts/kconfig/conf.o
  YACC    scripts/kconfig/zconf.tab.c
  LEX     scripts/kconfig/zconf.lex.c
  HOSTCC  scripts/kconfig/zconf.tab.o
  HOSTLD  scripts/kconfig/conf
scripts/kconfig/conf  --oldconfig Kconfig
#
# using defaults found in /boot/config-4.15.0-112-generic
#
/boot/config-4.15.0-112-generic:897:warning: symbol value 'm' invalid for HOTPLUG_PCI_SHPC
/boot/config-4.15.0-112-generic:1151:warning: symbol value 'm' invalid for NF_NAT_REDIRECT
/boot/config-4.15.0-112-generic:1154:warning: symbol value 'm' invalid for NF_TABLES_INET
/boot/config-4.15.0-112-generic:1155:warning: symbol value 'm' invalid for NF_TABLES_NETDEV
/boot/config-4.15.0-112-generic:1338:warning: symbol value 'm' invalid for NF_TABLES_IPV4
/boot/config-4.15.0-112-generic:1343:warning: symbol value 'm' invalid for NF_TABLES_ARP
/boot/config-4.15.0-112-generic:1350:warning: symbol value 'm' invalid for NF_NAT_MASQUERADE_I
PV4
/boot/config-4.15.0-112-generic:1385:warning: symbol value 'm' invalid for NF_TABLES_IPV6
/boot/config-4.15.0-112-generic:1397:warning: symbol value 'm' invalid for NF_NAT_MASQUERADE_I
PV6
/boot/config-4.15.0-112-generic:1423:warning: symbol value 'm' invalid for NF_TABLES_BRIDGE
```

12-

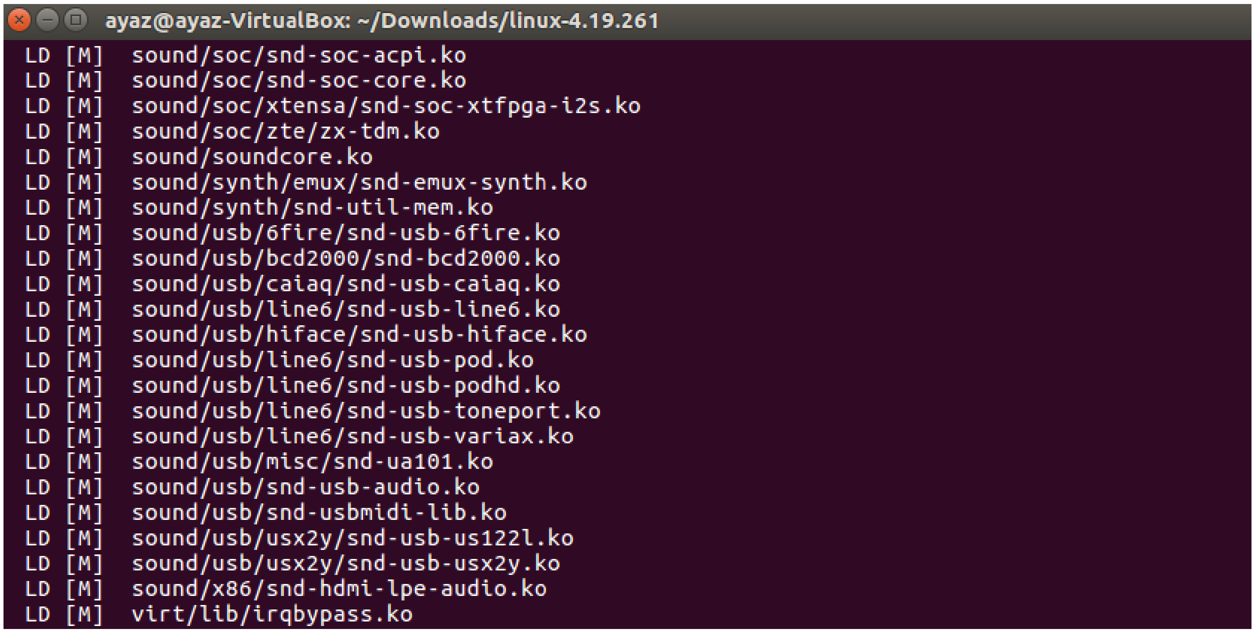
Now clean all the old and existing object using the command “make clean -j4” (note:here i used j4 because i set the 4 cores for the linux you can check your cpu cores by using this command “lscpu”).

Now using the command “make -j4” and it will start compilation for kernel.



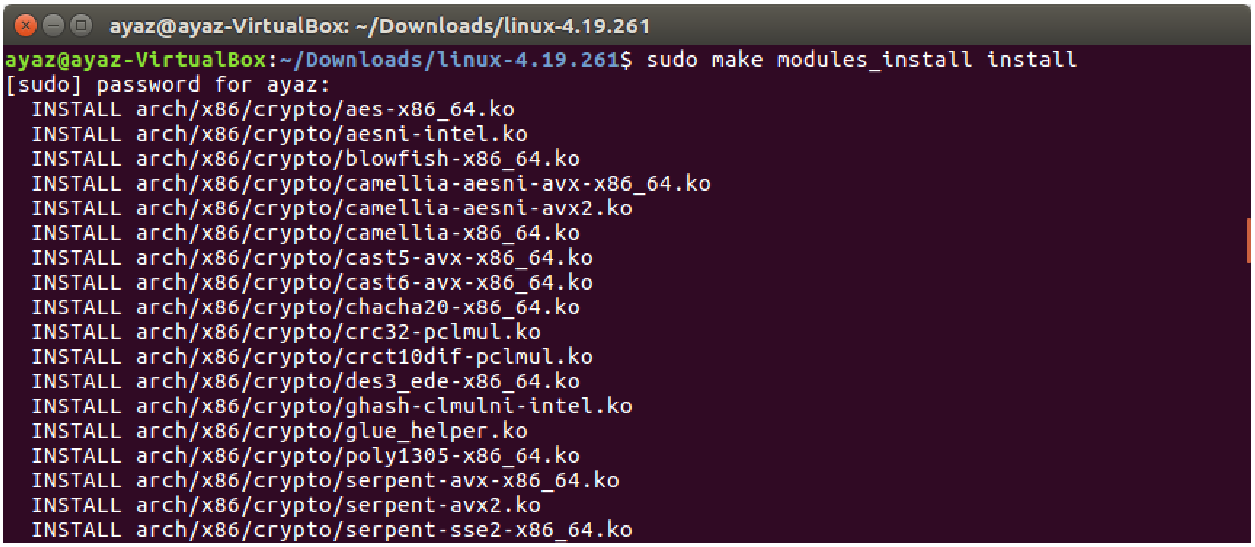
```
#
# configuration written to .config
#
ayaz@ayaz-VirtualBox:~/Downloads/linux-4.19.261$ sudo make clean -j4
ayaz@ayaz-VirtualBox:~/Downloads/linux-4.19.261$ sudo make -j4
```

It will take some time depend on your pc/laptop processor

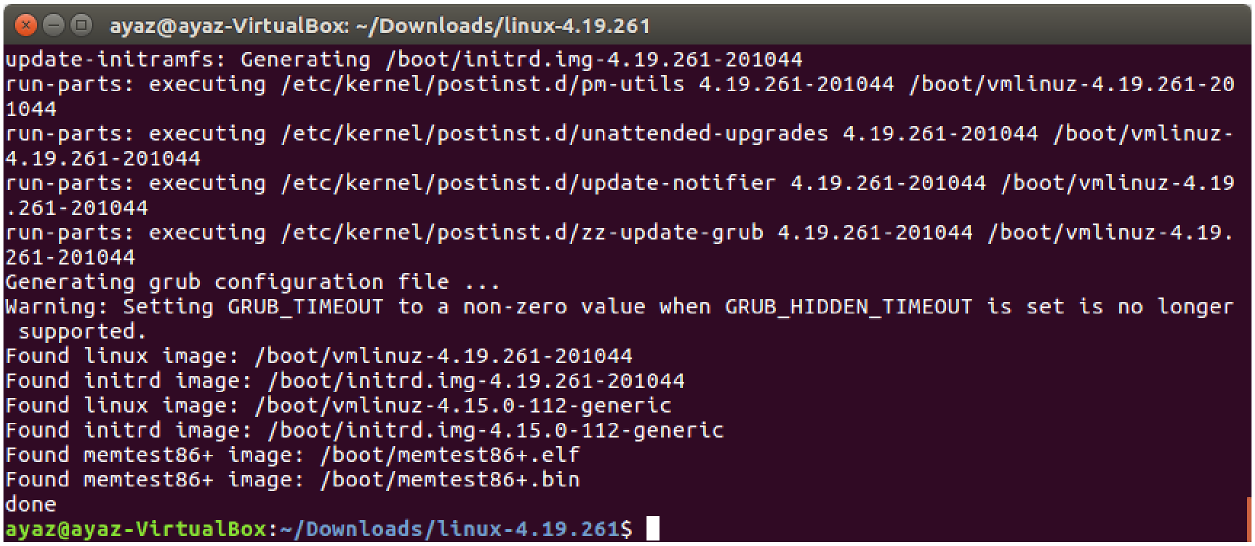


```
  LD [M]  sound/soc/snd-soc-acpi.ko
  LD [M]  sound/soc/snd-soc-core.ko
  LD [M]  sound/soc/xtensa/snd-soc-xtfpga-i2s.ko
  LD [M]  sound/soc/zte/zx-tdm.ko
  LD [M]  sound/soundcore.ko
  LD [M]  sound/synth/emux/snd-emux-synth.ko
  LD [M]  sound/synth/snd-util-mem.ko
  LD [M]  sound/usb/6fire/snd-usb-6fire.ko
  LD [M]  sound/usb/bcd2000/snd-bcd2000.ko
  LD [M]  sound/usb/caiaq/snd-usb-caiaq.ko
  LD [M]  sound/usb/line6/snd-usb-line6.ko
  LD [M]  sound/usb/hiface/snd-usb-hiface.ko
  LD [M]  sound/usb/line6/snd-usb-pod.ko
  LD [M]  sound/usb/line6/snd-usb-podhd.ko
  LD [M]  sound/usb/line6/snd-usb-toneport.ko
  LD [M]  sound/usb/line6/snd-usb-variax.ko
  LD [M]  sound/usb/misc/snd-ua101.ko
  LD [M]  sound/usb/snd-usb-audio.ko
  LD [M]  sound/usb/snd-usbmidi-lib.ko
  LD [M]  sound/usb/usx2y/snd-usb-us122l.ko
  LD [M]  sound/usb/usx2y/snd-usb-usx2y.ko
  LD [M]  sound/x86/snd-hdmi-lpe-audio.ko
  LD [M]  virt/lib/irqbypass.ko
```

13-
Now when it is done we have to install the kernel using the command “make modules_install install" .And wait until it shows the message “done”.



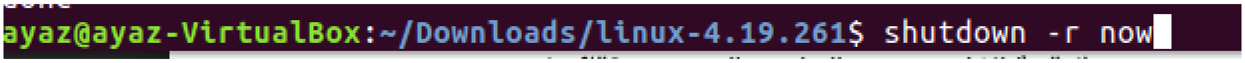
```
ayaz@ayaz-VirtualBox:~/Downloads/linux-4.19.261$ sudo make modules_install install
[sudo] password for ayaz:
  INSTALL arch/x86/crypto/aes-x86_64.ko
  INSTALL arch/x86/crypto/aesni-intel.ko
  INSTALL arch/x86/crypto/blowfish-x86_64.ko
  INSTALL arch/x86/crypto/camellia-aesni-avx-x86_64.ko
  INSTALL arch/x86/crypto/camellia-aesni-avx2.ko
  INSTALL arch/x86/crypto/camellia-x86_64.ko
  INSTALL arch/x86/crypto/cast5-avx-x86_64.ko
  INSTALL arch/x86/crypto/cast6-avx-x86_64.ko
  INSTALL arch/x86/crypto/chacha20-x86_64.ko
  INSTALL arch/x86/crypto/crc32-pclmul.ko
  INSTALL arch/x86/crypto/crct10dif-pclmul.ko
  INSTALL arch/x86/crypto/des3_ede-x86_64.ko
  INSTALL arch/x86/crypto/ghash-clmulni-intel.ko
  INSTALL arch/x86/crypto/glue_helper.ko
  INSTALL arch/x86/crypto/poly1305-x86_64.ko
  INSTALL arch/x86/crypto/serpent-avx-x86_64.ko
  INSTALL arch/x86/crypto/serpent-avx2.ko
  INSTALL arch/x86/crypto/serpent-sse2-x86_64.ko
```



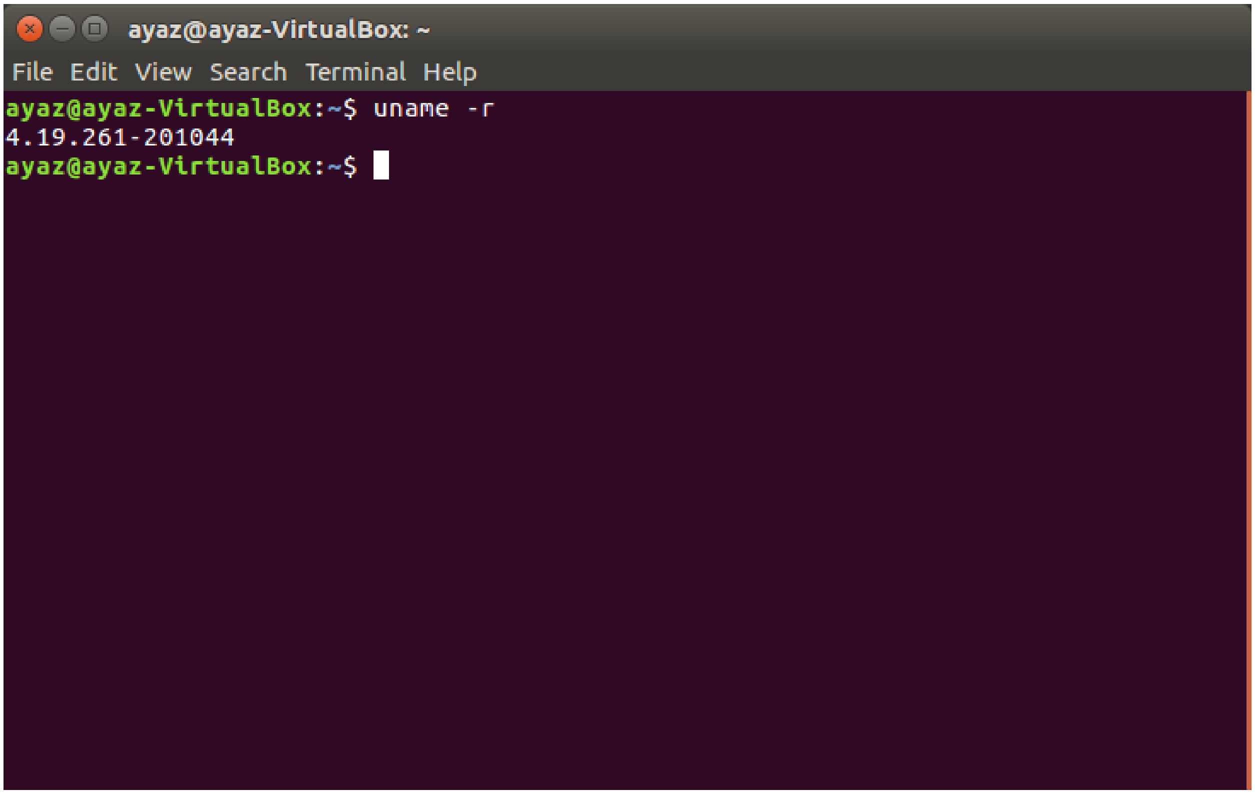
```
ayaz@ayaz-VirtualBox: ~/Downloads/linux-4.19.261
update-initramfs: Generating /boot/initrd.img-4.19.261-201044
run-parts: executing /etc/kernel/postinst.d/pm-utils 4.19.261-201044 /boot/vmlinuz-4.19.261-20
1044
run-parts: executing /etc/kernel/postinst.d/unattended-upgrades 4.19.261-201044 /boot/vmlinuz-
4.19.261-201044
run-parts: executing /etc/kernel/postinst.d/update-notifier 4.19.261-201044 /boot/vmlinuz-4.19
.261-201044
run-parts: executing /etc/kernel/postinst.d/zz-update-grub 4.19.261-201044 /boot/vmlinuz-4.19.
261-201044
Generating grub configuration file ...
Warning: Setting GRUB_TIMEOUT to a non-zero value when GRUB_HIDDEN_TIMEOUT is set is no longer
 supported.
Found linux image: /boot/vmlinuz-4.19.261-201044
Found initrd image: /boot/initrd.img-4.19.261-201044
Found linux image: /boot/vmlinuz-4.15.0-112-generic
Found initrd image: /boot/initrd.img-4.15.0-112-generic
Found memtest86+ image: /boot/memtest86+.elf
Found memtest86+ image: /boot/memtest86+.bin
done
ayaz@ayaz-VirtualBox:~/Downloads/linux-4.19.261$
```

14-

Now using the command “shutdown -r now” and restart your linux and it will set to your current linux.You can check this by using the command “uname -r” it will show the linux version with your roll number”



```
ayaz@ayaz-VirtualBox:~/Downloads/linux-4.19.261$ shutdown -r now
```



```
ayaz@ayaz-VirtualBox:~$ uname -r
4.19.261-201044
ayaz@ayaz-VirtualBox:~$ 
```

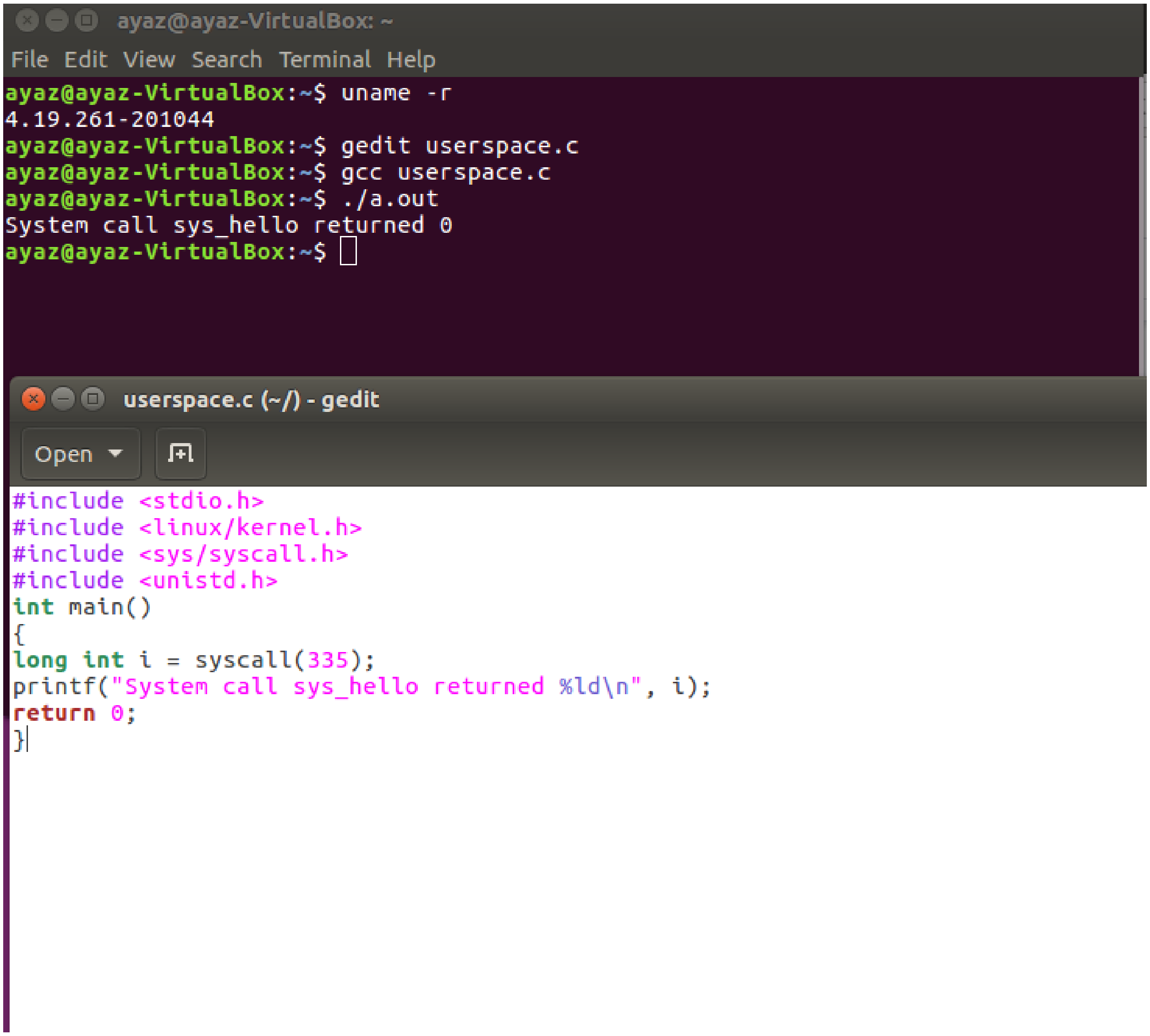
15-

Now check weather the system call is working properly or not make the .c file and add the following code

```
#include <stdio.h>
#include <linux/kernel.h>
#include <sys/syscall.h>
#include <unistd.h>
int main()
```

```
{
long int i = syscall(335);
printf("System call sys_hello returned %ld\n", i);
return 0;
}
```

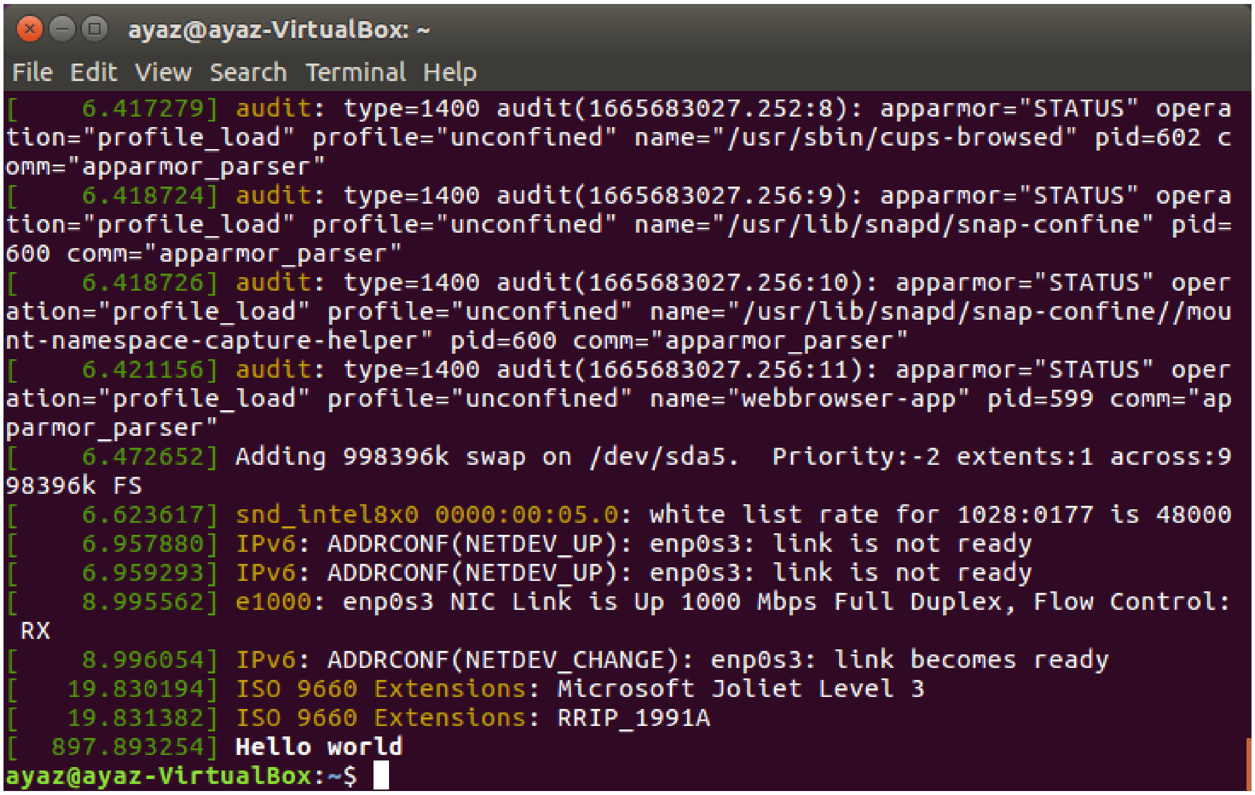
Now compile the code using gcc command if it return 0 then it means system call working fine.



```
ayaz@ayaz-VirtualBox:~$ uname -r
4.19.261-201044
ayaz@ayaz-VirtualBox:~$ gedit userspace.c
ayaz@ayaz-VirtualBox:~$ gcc userspace.c
ayaz@ayaz-VirtualBox:~$ ./a.out
System call sys_hello returned 0
ayaz@ayaz-VirtualBox:~$ 
```

```
#include <stdio.h>
#include <linux/kernel.h>
#include <sys/syscall.h>
#include <unistd.h>
int main()
{
long int i = syscall(335);
printf("System call sys_hello returned %ld\n", i);
return 0;
}
```

Now using the command “dmesg” it will show the kennel message “Hello World”.



```
[    6.417279] audit: type=1400 audit(1665683027.252:8): apparmor="STATUS" opera
tion="profile_load" profile="unconfined" name="/usr/sbin/cups-browsed" pid=602 c
omm="apparmor_parser"
[    6.418724] audit: type=1400 audit(1665683027.256:9): apparmor="STATUS" opera
tion="profile_load" profile="unconfined" name="/usr/lib/snapd/snap-confine" pid=
600 comm="apparmor_parser"
[    6.418726] audit: type=1400 audit(1665683027.256:10): apparmor="STATUS" oper
ation="profile_load" profile="unconfined" name="/usr/lib/snapd/snap-confine//mou
nt-namespace-capture-helper" pid=600 comm="apparmor_parser"
[    6.421156] audit: type=1400 audit(1665683027.256:11): apparmor="STATUS" oper
ation="profile_load" profile="unconfined" name="webbrowser-app" pid=599 comm="ap
parmor_parser"
[    6.472652] Adding 998396k swap on /dev/sda5.  Priority:-2 extents:1 across:9
98396k FS
[    6.623617] snd_intel8x0 0000:00:05.0: white list rate for 1028:0177 is 48000
[    6.957880] IPv6: ADDRCONF(NETDEV_UP): enp0s3: link is not ready
[    6.959293] IPv6: ADDRCONF(NETDEV_UP): enp0s3: link is not ready
[    8.995562] e1000: enp0s3 NIC Link is Up 1000 Mbps Full Duplex, Flow Control:
 RX
[    8.996054] IPv6: ADDRCONF(NETDEV_CHANGE): enp0s3: link becomes ready
[   19.830194] ISO 9660 Extensions: Microsoft Joliet Level 3
[   19.831382] ISO 9660 Extensions: RRIP_1991A
[  897.893254] Hello world
ayaz@ayaz-VirtualBox:~$ 
```