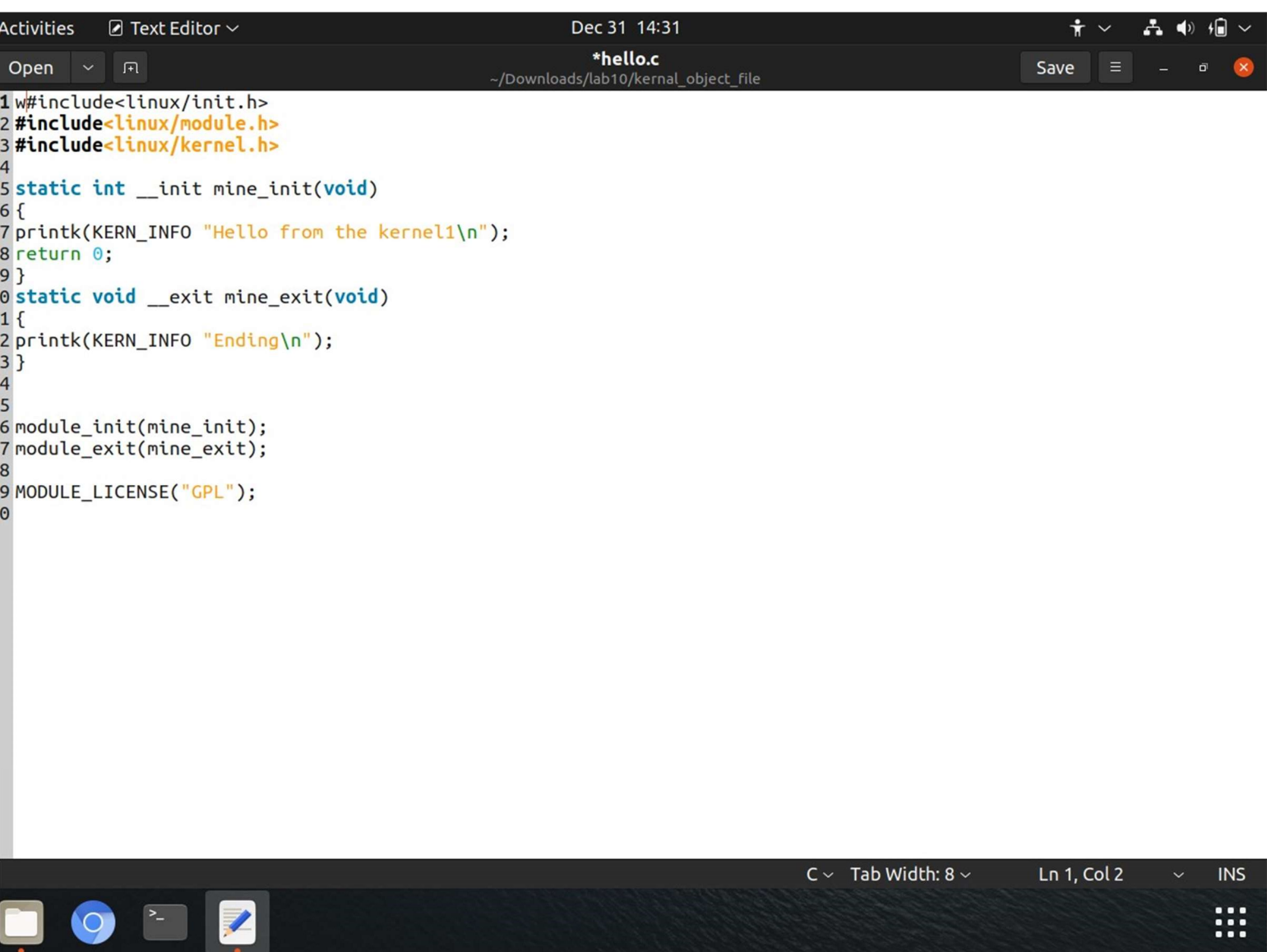


**TASK:**

[1] Write a Loadable Kernel module.

**CODE:**

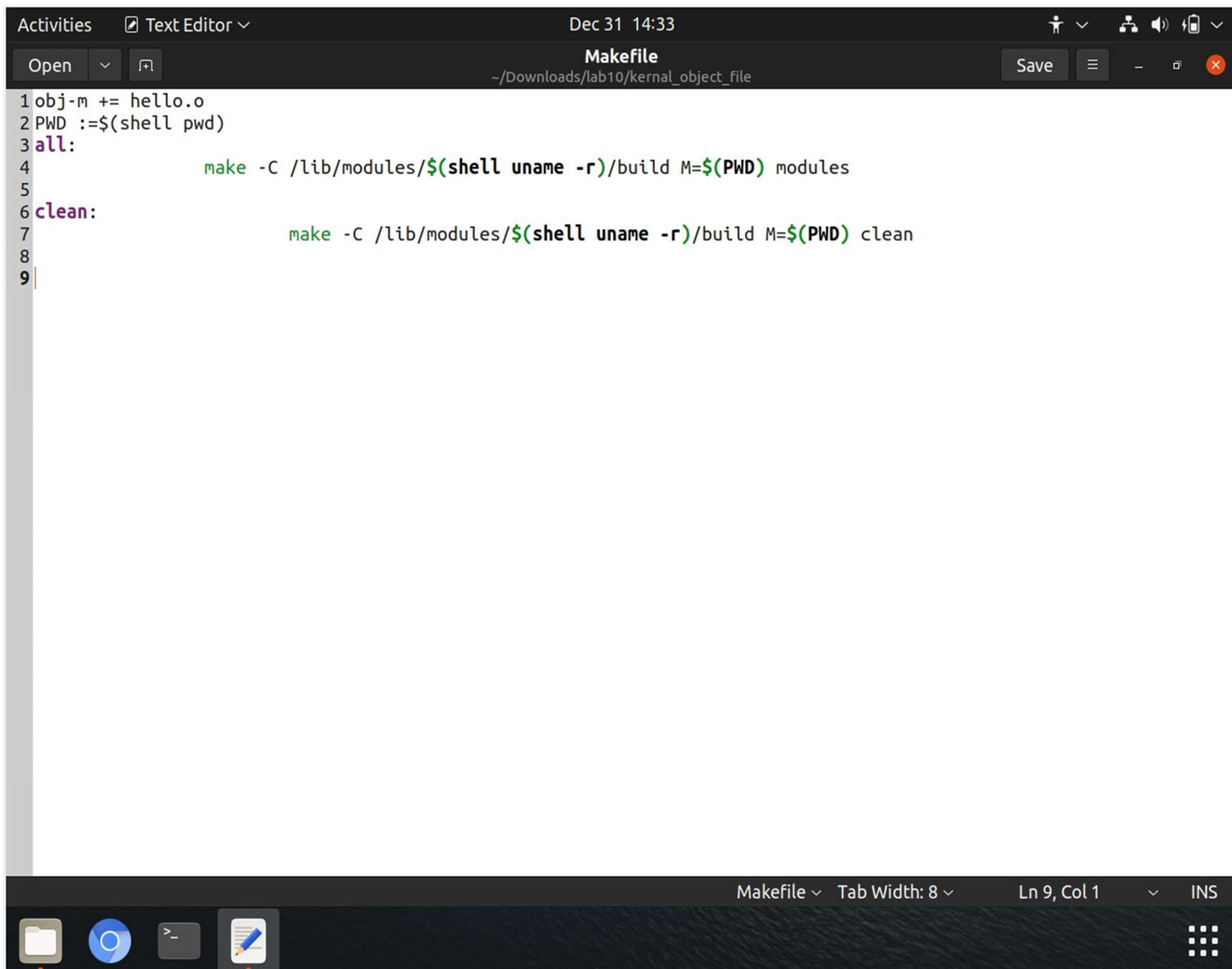
**C FILE:**



The screenshot shows a Linux desktop environment. At the top, there is a panel with 'Activities', 'Text Editor', and the date/time 'Dec 31 14:31'. Below this is a window titled '\*hello.c' with a path '~/.Downloads/lab10/kernal\_object\_file'. The window contains C code for a kernel module. The code includes headers for `linux/init.h`, `linux/module.h`, and `linux/kernel.h`. It defines two functions: `__init mine_init(void)` which prints 'Hello from the kernel1\n' and `__exit mine_exit(void)` which prints 'Ending\n'. The module is initialized with `module_init(mine_init)` and exited with `module_exit(mine_exit)`. The license is set to 'GPL'. The status bar at the bottom shows 'C', 'Tab Width: 8', 'Ln 1, Col 2', and 'INS'. The taskbar at the very bottom contains icons for a file manager, a web browser, a terminal, and the text editor.

```
1 #include<linux/init.h>
2 #include<linux/module.h>
3 #include<linux/kernel.h>
4
5 static int __init mine_init(void)
6 {
7     printk(KERN_INFO "Hello from the kernel1\n");
8     return 0;
9 }
10 static void __exit mine_exit(void)
11 {
12     printk(KERN_INFO "Ending\n");
13 }
14
15 module_init(mine_init);
16 module_exit(mine_exit);
17 MODULE_LICENSE("GPL");
18
```

## MAKEFILE:

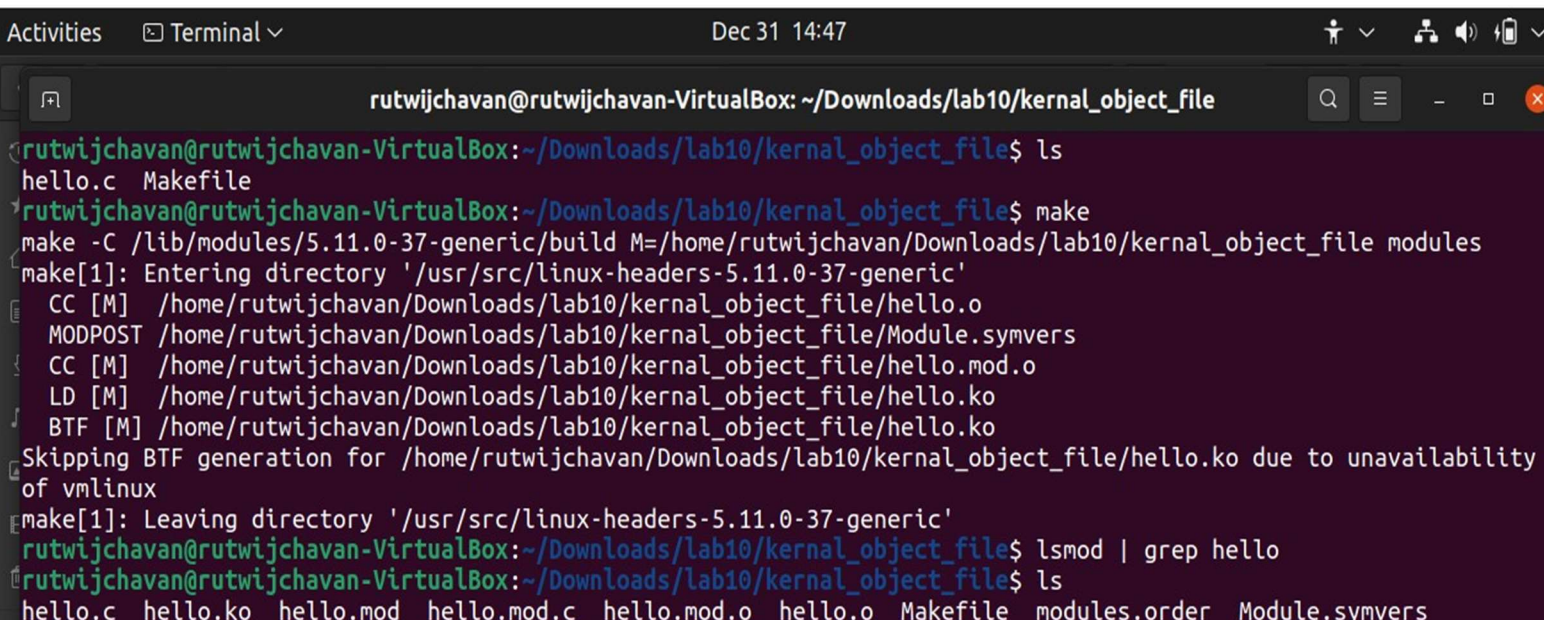


The screenshot shows a text editor window titled 'Makefile' with the path '~/Downloads/lab10/kernal\_object\_file'. The editor contains the following Makefile content:

```
1 obj-m += hello.o
2 PWD :=$(shell pwd)
3 all:
4     make -C /lib/modules/$(shell uname -r)/build M=$(PWD) modules
5
6 clean:
7     make -C /lib/modules/$(shell uname -r)/build M=$(PWD) clean
8
9
```

The editor's status bar at the bottom indicates 'Makefile', 'Tab Width: 8', 'Ln 9, Col 1', and 'INS'.

## OUTPUT: MAKE:



The screenshot shows a terminal window titled 'rutwijchavan@rutwijchavan-VirtualBox: ~/Downloads/lab10/kernal\_object\_file'. The terminal displays the following output:

```
rutwijchavan@rutwijchavan-VirtualBox:~/Downloads/lab10/kernal_object_file$ ls
hello.c Makefile
rutwijchavan@rutwijchavan-VirtualBox:~/Downloads/lab10/kernal_object_file$ make
make -C /lib/modules/5.11.0-37-generic/build M=/home/rutwijchavan/Downloads/lab10/kernal_object_file modules
make[1]: Entering directory '/usr/src/linux-headers-5.11.0-37-generic'
  CC [M] /home/rutwijchavan/Downloads/lab10/kernal_object_file/hello.o
  MODPOST /home/rutwijchavan/Downloads/lab10/kernal_object_file/Module.symvers
  CC [M] /home/rutwijchavan/Downloads/lab10/kernal_object_file/hello.mod.o
  LD [M] /home/rutwijchavan/Downloads/lab10/kernal_object_file/hello.ko
  BTF [M] /home/rutwijchavan/Downloads/lab10/kernal_object_file/hello.ko
Skipping BTF generation for /home/rutwijchavan/Downloads/lab10/kernal_object_file/hello.ko due to unavailability
of vmlinux
make[1]: Leaving directory '/usr/src/linux-headers-5.11.0-37-generic'
rutwijchavan@rutwijchavan-VirtualBox:~/Downloads/lab10/kernal_object_file$ lsmod | grep hello
rutwijchavan@rutwijchavan-VirtualBox:~/Downloads/lab10/kernal_object_file$ ls
hello.c hello.ko hello.mod hello.mod.c hello.mod.o hello.o Makefile modules.order Module.symvers
```



## KERNEL MODULE INSERTION , DEBUG AND REMOVE:

```
Activities Terminal Dec 31 14:52
rutwijchavan@rutwijchavan-VirtualBox: ~/Downloads/lab10/kernel_object_file

rutwijchavan@rutwijchavan-VirtualBox:~/Downloads/lab10/kernel_object_file$ insmod hello.ko
insmod: ERROR: could not insert module hello.ko: Operation not permitted

rutwijchavan@rutwijchavan-VirtualBox:~/Downloads/lab10/kernel_object_file$ sudo insmod hello.ko
[sudo] password for rutwijchavan:
rutwijchavan@rutwijchavan-VirtualBox:~/Downloads/lab10/kernel_object_file$ lsmod | grep hello
hello                16384  0
rutwijchavan@rutwijchavan-VirtualBox:~/Downloads/lab10/kernel_object_file$ sudo sysctl kernel.dmesg_restrict=0
kernel.dmesg_restrict = 0
rutwijchavan@rutwijchavan-VirtualBox:~/Downloads/lab10/kernel_object_file$ dmesg | tail
[ 39.113562] audit: type=1107 audit(1640940806.700:46): pid=653 uid=103 auid=4294967295 ses=4294967295 subj=unc
onfined msg='apparmor="DENIED" operation="dbus_method_call" bus="system" path="/org/freedesktop/PolicyKit1/Autho
rity" interface="org.freedesktop.PolicyKit1.Authority" member="CheckAuthorization" mask="send" name=":1.5" pid=24
33 label="snap.snap-store.ubuntu-software" peer_pid=663 peer_label="unconfined"
exe="/usr/bin/dbus-daemon" sauid=103 hostname=? addr=? terminal=?'
[ 39.149137] audit: type=1107 audit(1640940806.736:47): pid=653 uid=103 auid=4294967295 ses=4294967295 subj=unc
onfined msg='apparmor="DENIED" operation="dbus_method_call" bus="system" path="/org/freedesktop/PolicyKit1/Autho
rity" interface="org.freedesktop.DBus.Properties" member="GetAll" mask="send" name=":1.5" pid=2433 label="snap.sn
ap-store.ubuntu-software" peer_pid=663 peer_label="unconfined"
exe="/usr/bin/dbus-daemon" sauid=103 hostname=? addr=? terminal=?'
[ 39.149657] audit: type=1107 audit(1640940806.736:48): pid=653 uid=103 auid=4294967295 ses=4294967295 subj=unc
onfined msg='apparmor="DENIED" operation="dbus_method_call" bus="system" path="/org/freedesktop/PolicyKit1/Autho
rity" interface="org.freedesktop.PolicyKit1.Authority" member="CheckAuthorization" mask="send" name=":1.5" pid=24
33 label="snap.snap-store.ubuntu-software" peer_pid=663 peer_label="unconfined"
exe="/usr/bin/dbus-daemon" sauid=103 hostname=? addr=? terminal=?'
[ 40.367220] audit: type=1400 audit(1640940807.952:49): apparmor="DENIED" operation="open" profile="snap.snap-s
tore.ubuntu-software" name="/etc/PackageKit/Vendor.conf" pid=2433 comm="snap-store" requested_mask="r" denied_mas
k="r" fsuid=1000 ouid=0
[ 993.279328] hello: loading out-of-tree module taints kernel.
[ 993.279358] hello: module verification failed: signature and/or required key missing - tainting kernel
[ 993.280188] Hello from the kernel1
rutwijchavan@rutwijchavan-VirtualBox:~/Downloads/lab10/kernel_object_file$ dmesg | tail >>text1.txt
rutwijchavan@rutwijchavan-VirtualBox:~/Downloads/lab10/kernel_object_file$ sudo rmmod hello.ko

rutwijchavan@rutwijchavan-VirtualBox:~/Downloads/lab10/kernel_object_file$ lsmod | grep hello
rutwijchavan@rutwijchavan-VirtualBox:~/Downloads/lab10/kernel_object_file$ dmesg | tail
exe="/usr/bin/dbus-daemon" sauid=103 hostname=? addr=? terminal=?'
[ 39.149137] audit: type=1107 audit(1640940806.736:47): pid=653 uid=103 auid=4294967295 ses=4294967295 subj=unc
onfined msg='apparmor="DENIED" operation="dbus_method_call" bus="system" path="/org/freedesktop/PolicyKit1/Autho
rity" interface="org.freedesktop.DBus.Properties" member="GetAll" mask="send" name=":1.5" pid=2433 label="snap.sn
ap-store.ubuntu-software" peer_pid=663 peer_label="unconfined"
exe="/usr/bin/dbus-daemon" sauid=103 hostname=? addr=? terminal=?'
[ 39.149657] audit: type=1107 audit(1640940806.736:48): pid=653 uid=103 auid=4294967295 ses=4294967295 subj=unc
onfined msg='apparmor="DENIED" operation="dbus_method_call" bus="system" path="/org/freedesktop/PolicyKit1/Autho
rity" interface="org.freedesktop.PolicyKit1.Authority" member="CheckAuthorization" mask="send" name=":1.5" pid=24
33 label="snap.snap-store.ubuntu-software" peer_pid=663 peer_label="unconfined"
exe="/usr/bin/dbus-daemon" sauid=103 hostname=? addr=? terminal=?'
[ 40.367220] audit: type=1400 audit(1640940807.952:49): apparmor="DENIED" operation="open" profile="snap.snap-s
tore.ubuntu-software" name="/etc/PackageKit/Vendor.conf" pid=2433 comm="snap-store" requested_mask="r" denied_mas
k="r" fsuid=1000 ouid=0
[ 993.279328] hello: loading out-of-tree module taints kernel.
[ 993.279358] hello: module verification failed: signature and/or required key missing - tainting kernel
[ 993.280188] Hello from the kernel1
[ 1384.295619] Ending
rutwijchavan@rutwijchavan-VirtualBox:~/Downloads/lab10/kernel_object_file$ dmesg | tail >>text2.txt
rutwijchavan@rutwijchavan-VirtualBox:~/Downloads/lab10/kernel_object_file$ ls
hello.c  hello.mod  hello.mod.o  Makefile  Module.symvers  text2.txt
hello.ko  hello.mod.c  hello.o  modules.order  text1.txt
rutwijchavan@rutwijchavan-VirtualBox:~/Downloads/lab10/kernel_object_file$
```



## TEXT1: {AFTER INSERT MODULE}

```
Activities Text Editor Dec 31 14:57
text1.txt
~/Downloads/lab10/kernel_object_file
Save

1 [ 39.113562] audit: type=1107 audit(1640940806.700:46): pid=653 uid=103 auid=4294967295 ses=4294967295
  subj=unconfined msg='apparmor="DENIED" operation="dbus_method_call" bus="system" path="/org/freedesktop/-
  PolicyKit1/Authority" interface="org.freedesktop.PolicyKit1.Authority" member="CheckAuthorization" mask="send"
  name=":1.5" pid=2433 label="snap.snap-store.ubuntu-software" peer_pid=663 peer_label="unconfined"
2     exe="/usr/bin/dbus-daemon" sauid=103 hostname=? addr=? terminal=?'
3 [ 39.149137] audit: type=1107 audit(1640940806.736:47): pid=653 uid=103 auid=4294967295 ses=4294967295
  subj=unconfined msg='apparmor="DENIED" operation="dbus_method_call" bus="system" path="/org/freedesktop/-
  PolicyKit1/Authority" interface="org.freedesktop.DBus.Properties" member="GetAll" mask="send" name=":1.5"
  pid=2433 label="snap.snap-store.ubuntu-software" peer_pid=663 peer_label="unconfined"
4     exe="/usr/bin/dbus-daemon" sauid=103 hostname=? addr=? terminal=?'
5 [ 39.149657] audit: type=1107 audit(1640940806.736:48): pid=653 uid=103 auid=4294967295 ses=4294967295
  subj=unconfined msg='apparmor="DENIED" operation="dbus_method_call" bus="system" path="/org/freedesktop/-
  PolicyKit1/Authority" interface="org.freedesktop.PolicyKit1.Authority" member="CheckAuthorization" mask="send"
  name=":1.5" pid=2433 label="snap.snap-store.ubuntu-software" peer_pid=663 peer_label="unconfined"
6     exe="/usr/bin/dbus-daemon" sauid=103 hostname=? addr=? terminal=?'
7 [ 40.367220] audit: type=1400 audit(1640940807.952:49): apparmor="DENIED" operation="open" profile="snap.snap-
  store.ubuntu-software" name="/etc/PackageKit/Vendor.conf" pid=2433 comm="snap-store" requested_mask="r"
  denied_mask="r" fsuid=1000 ouid=0
8 [ 993.279328] hello: loading out-of-tree module taints kernel.
9 [ 993.279358] hello: module verification failed: signature and/or required key missing - tainting kernel
10 [ 993.280188] Hello from the kernel1

Plain Text Tab Width: 8 Ln 1, Col 1 INS
```

## TEXT2: {AFTER MODULE REMOVE}

```
Activities Text Editor Dec 31 15:00
text2.txt
~/Downloads/lab10/kernel_object_file
Save

1     exe="/usr/bin/dbus-daemon" sauid=103 hostname=? addr=? terminal=?'
2 [ 39.149137] audit: type=1107 audit(1640940806.736:47): pid=653 uid=103 auid=4294967295 ses=4294967295
  subj=unconfined msg='apparmor="DENIED" operation="dbus_method_call" bus="system" path="/org/freedesktop/-
  PolicyKit1/Authority" interface="org.freedesktop.DBus.Properties" member="GetAll" mask="send" name=":1.5"
  pid=2433 label="snap.snap-store.ubuntu-software" peer_pid=663 peer_label="unconfined"
3     exe="/usr/bin/dbus-daemon" sauid=103 hostname=? addr=? terminal=?'
4 [ 39.149657] audit: type=1107 audit(1640940806.736:48): pid=653 uid=103 auid=4294967295 ses=4294967295
  subj=unconfined msg='apparmor="DENIED" operation="dbus_method_call" bus="system" path="/org/freedesktop/-
  PolicyKit1/Authority" interface="org.freedesktop.PolicyKit1.Authority" member="CheckAuthorization" mask="send"
  name=":1.5" pid=2433 label="snap.snap-store.ubuntu-software" peer_pid=663 peer_label="unconfined"
5     exe="/usr/bin/dbus-daemon" sauid=103 hostname=? addr=? terminal=?'
6 [ 40.367220] audit: type=1400 audit(1640940807.952:49): apparmor="DENIED" operation="open" profile="snap.snap-
  store.ubuntu-software" name="/etc/PackageKit/Vendor.conf" pid=2433 comm="snap-store" requested_mask="r"
  denied_mask="r" fsuid=1000 ouid=0
7 [ 993.279328] hello: loading out-of-tree module taints kernel.
8 [ 993.279358] hello: module verification failed: signature and/or required key missing - tainting kernel
9 [ 993.280188] Hello from the kernel1
10 [ 1384.295619] Ending

Loading file "/home/rutwijchavan/Downloads/lab10/kernel_object_file/text2.txt"... Plain Text Tab Width: 8 Ln 1, Col 1 INS
```