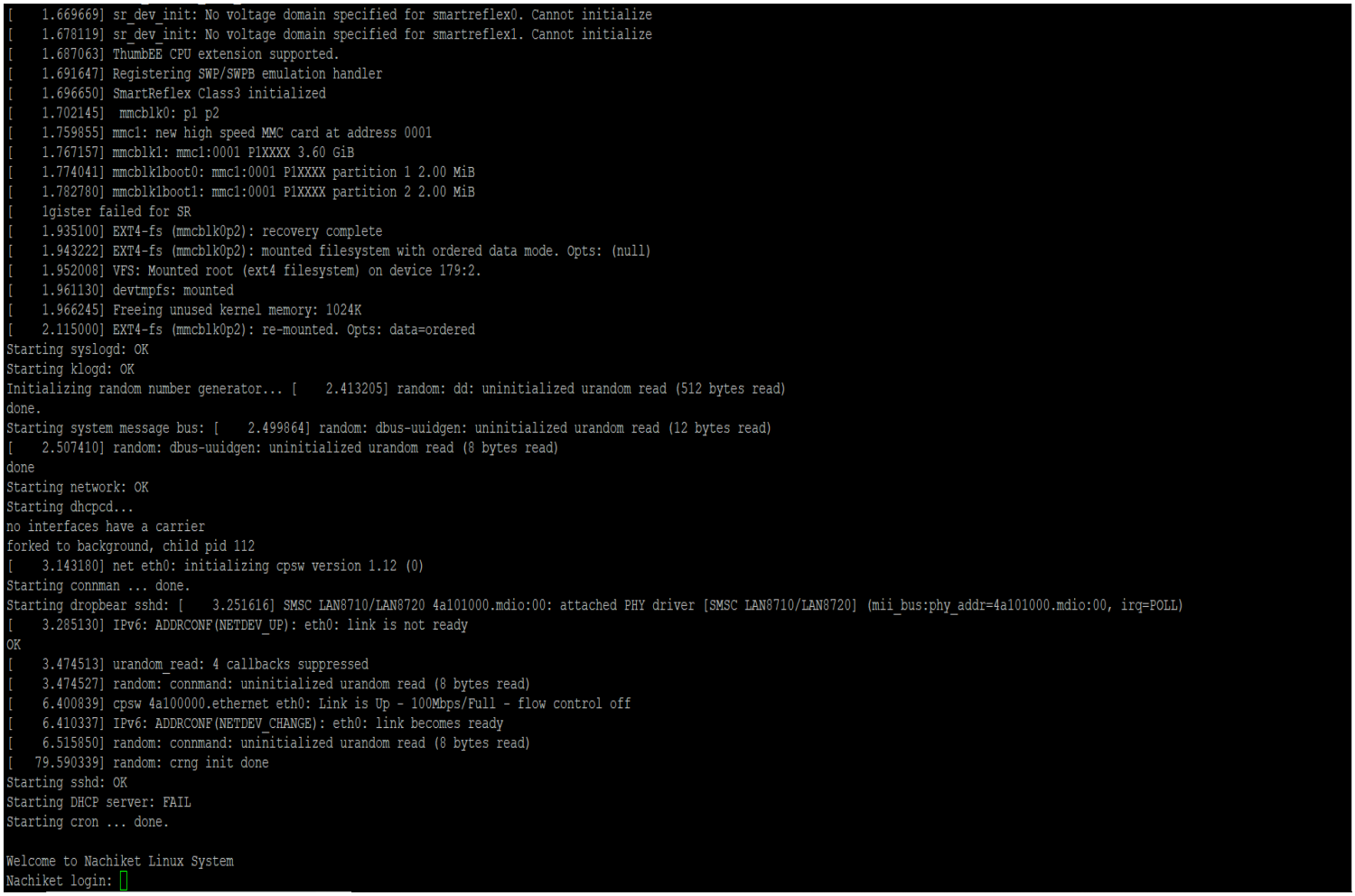
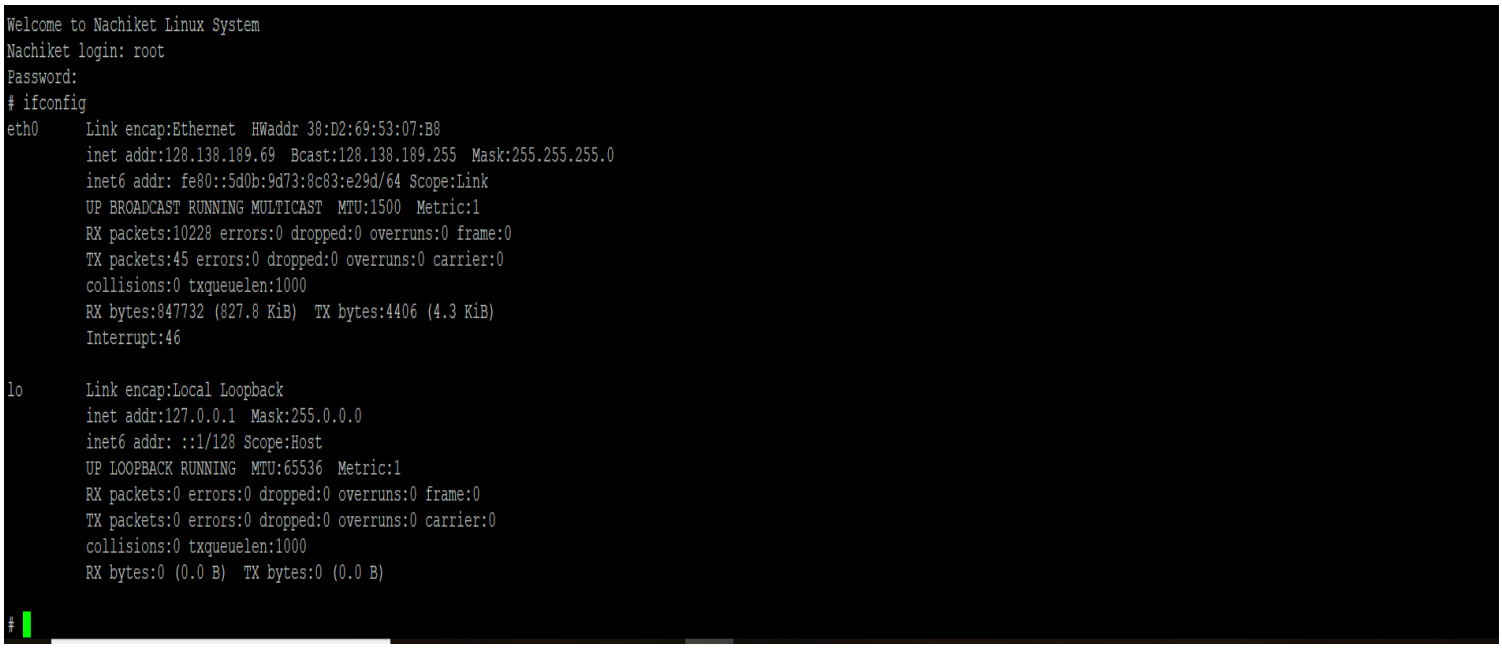
Problem 1: Setting up beagle bone green ethernet environment.

1. The boot messages.



2. The ethernet address.



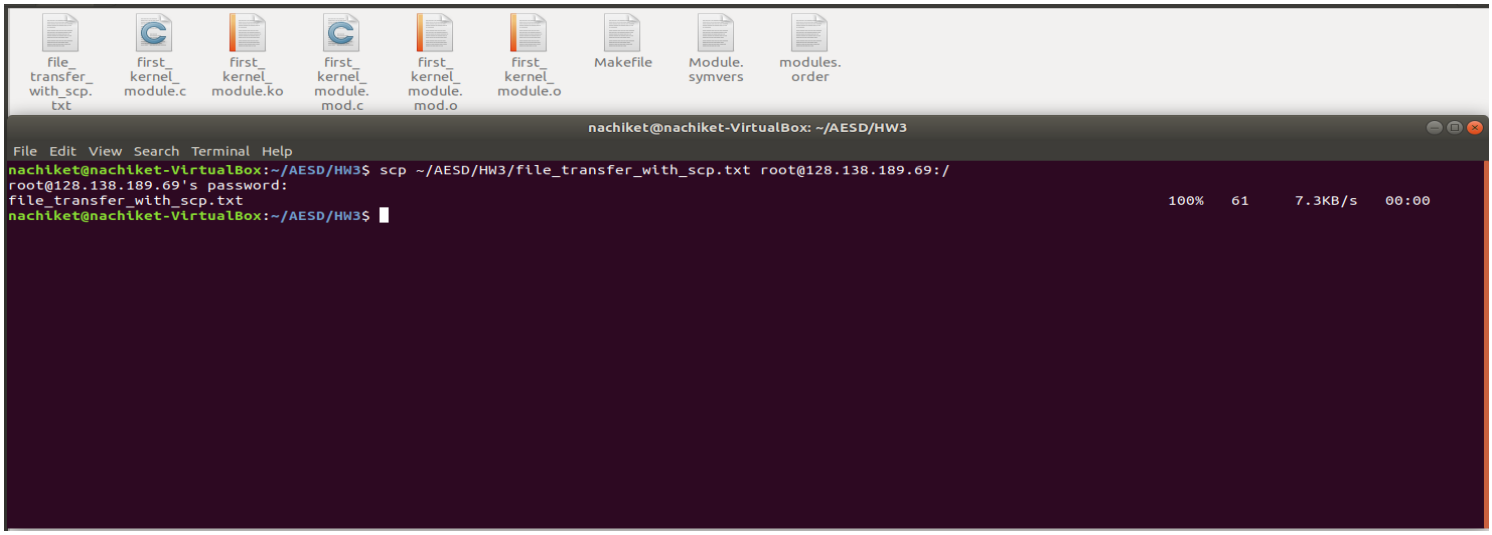
3. SSH

```
                                                                nachiket@nachiket-VirtualBox: ~
File  Edit  View  Search  Terminal  Help
nachiket@nachiket-VirtualBox:~$ xrandr -s 1920x1080
nachiket@nachiket-VirtualBox:~$ ssh root@128.138.189.69
The authenticity of host '128.138.189.69 (128.138.189.69)' can't be established.
ECDSA key fingerprint is SHA256:aky/6tAtdLGvz6GOASg11yuO4KkvmQrEEn3SXQATW3g.
Are you sure you want to continue connecting (yes/no)? nachi62244
Please type 'yes' or 'no': yes
Warning: Permanently added '128.138.189.69' (ECDSA) to the list of known hosts.
root@128.138.189.69's password:
# ls
#
```

4. Files in the beagle bone green before SCP (transfer of file.)

```
# ls
bin          etc          helloworld.c  lib32        lost+found  mnt          proc         run          sorting      tmp          track_calls.c  var
dev          helloworld   lib           linuxrc      media       opt          root         sbin         sys          track_calls  usr
```

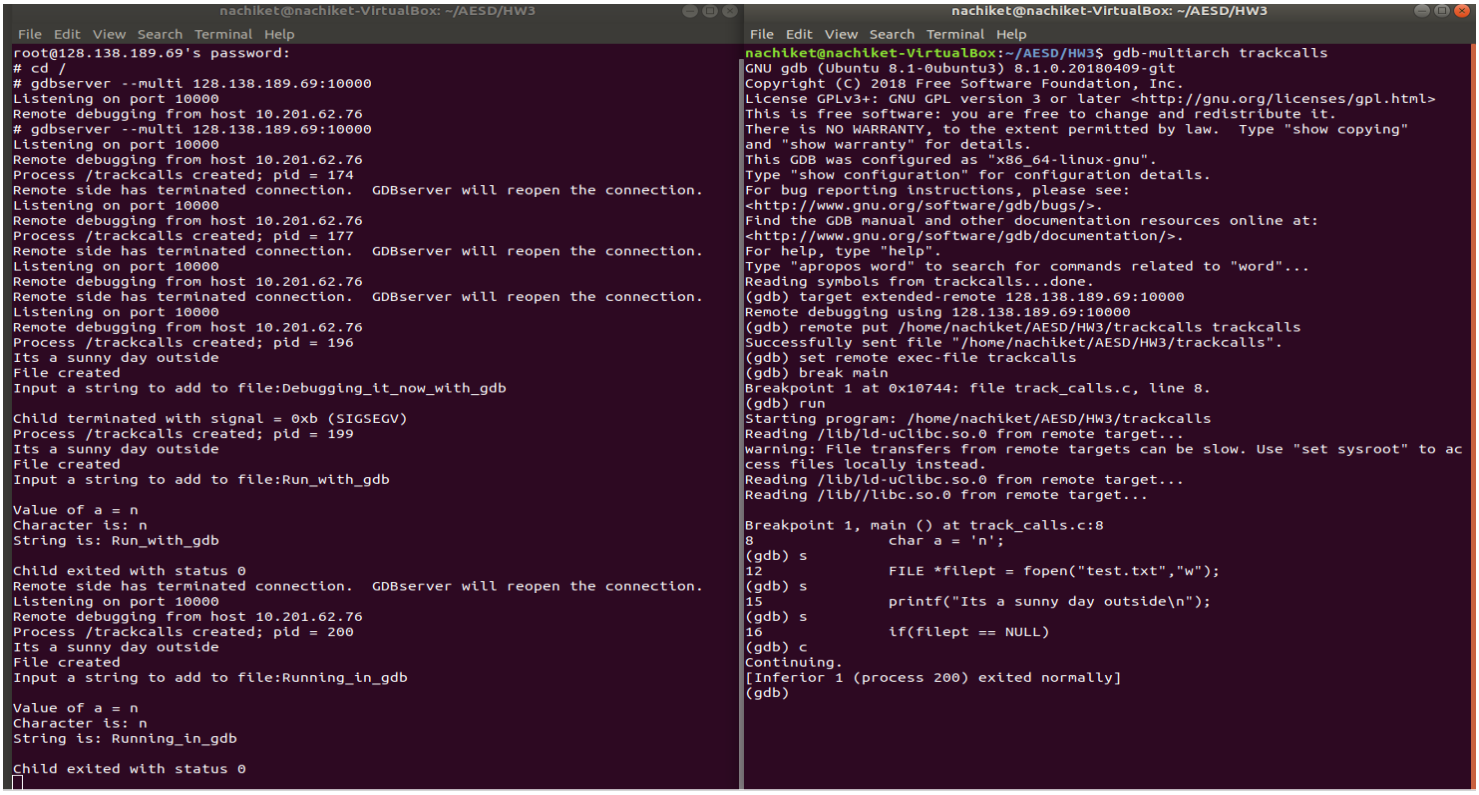
The scp command executed from linux terminal



Files in the beagle bone green after SCP transfer

```
# ls
bin                      helloworld.c  media        run          track_calls
dev                      lib           mnt          sbin         track_calls.c
etc                      lib32         opt          sorting      usr
file_transfer_with_scp.txt  linuxrc    proc         sys          var
helloworld               lost+found    root         tmp
#
```

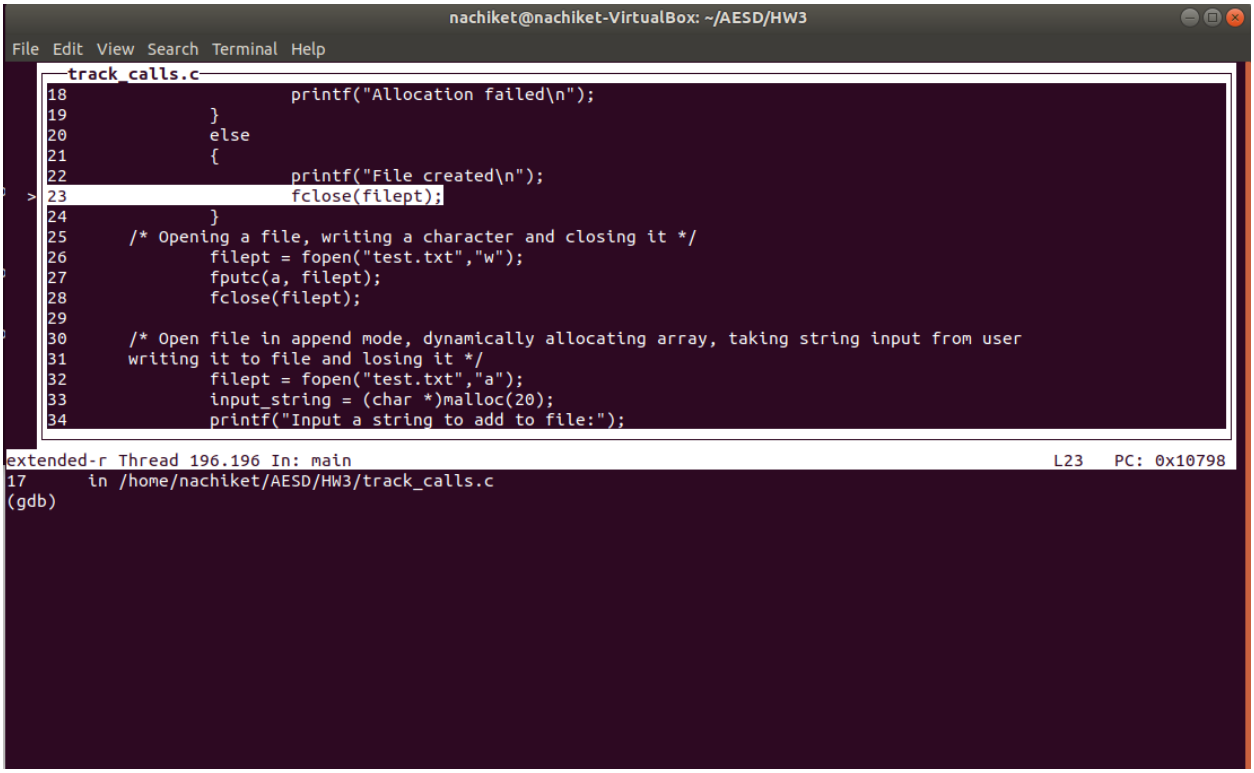
Remote debugging using GDB. All the required commands to be executed.



```
nachiket@nachiket-VirtualBox: ~/AESD/HW3
File  Edit  View  Search  Terminal  Help
root@128.138.189.69's password:
# cd /
# gdbserver --multi 128.138.189.69:10000
Listening on port 10000
Remote debugging from host 10.201.62.76
# gdbserver --multi 128.138.189.69:10000
Listening on port 10000
Remote debugging from host 10.201.62.76
Process /trackcalls created; pid = 174
Remote side has terminated connection.  GDBserver will reopen the connection.
Listening on port 10000
Remote debugging from host 10.201.62.76
Process /trackcalls created; pid = 177
Remote side has terminated connection.  GDBserver will reopen the connection.
Listening on port 10000
Remote debugging from host 10.201.62.76
Remote side has terminated connection.  GDBserver will reopen the connection.
Listening on port 10000
Remote debugging from host 10.201.62.76
Process /trackcalls created; pid = 196
Its a sunny day outside
File created
Input a string to add to file:Debugging_it_now_with_gdb

Child terminated with signal = 0xb (SIGSEGV)
Process /trackcalls created; pid = 199
Its a sunny day outside
File created
Input a string to add to file:Run_with_gdb

Value of a = n
Character is: n
String is: Run_with_gdb

Child exited with status 0
Remote side has terminated connection.  GDBserver will reopen the connection.
Listening on port 10000
Remote debugging from host 10.201.62.76
Process /trackcalls created; pid = 200
Its a sunny day outside
File created
Input a string to add to file:Running_in_gdb

Value of a = n
Character is: n
String is: Running_in_gdb

Child exited with status 0
```

```
nachiket@nachiket-VirtualBox: ~/AESD/HW3
File  Edit  View  Search  Terminal  Help
nachiket@nachiket-VirtualBox:~/AESD/HW3$ gdb-multiarch trackcalls
GNU gdb (Ubuntu 8.1-0ubuntu3) 8.1.0.20180409-git
Copyright (C) 2018 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <http://gnu.org/licenses/gpl.html>
This is free software: you are free to change and redistribute it.
There is NO WARRANTY, to the extent permitted by law.  Type "show copying"
and "show warranty" for details.
This GDB was configured as "x86_64-linux-gnu".
Type "show configuration" for configuration details.
For bug reporting instructions, please see:
<http://www.gnu.org/software/gdb/bugs/>.
Find the GDB manual and other documentation resources online at:
<http://www.gnu.org/software/gdb/documentation/>.
For help, type "help".
Type "apropos word" to search for commands related to "word"...
Reading symbols from trackcalls...done.
(gdb) target extended-remote 128.138.189.69:10000
Remote debugging using 128.138.189.69:10000
(gdb) remote put /home/nachiket/AESD/HW3/trackcalls trackcalls
Successfully sent file "/home/nachiket/AESD/HW3/trackcalls".
(gdb) set remote exec-file trackcalls
(gdb) break main
Breakpoint 1 at 0x10744: file track_calls.c, line 8.
(gdb) run
Starting program: /home/nachiket/AESD/HW3/trackcalls
Reading /lib/ld-uClibc.so.0 from remote target...
warning: File transfers from remote targets can be slow. Use "set sysroot" to ac
cess files locally instead.
Reading /lib/ld-uClibc.so.0 from remote target...
Reading /lib//libc.so.0 from remote target...

Breakpoint 1, main () at track_calls.c:8
8               char a = 'n';
(gdb) s
12              FILE *filept = fopen("test.txt","w");
(gdb) s
15              printf("Its a sunny day outside\n");
(gdb) s
16              if(filept == NULL)
(gdb) c
Continuing.
[Inferior 1 (process 200) exited normally]
(gdb)
```

Using terminal user interface



```
nachiket@nachiket-VirtualBox: ~/AESD/HW3
File  Edit  View  Search  Terminal  Help
 track_calls.c
18                      printf("Allocation failed\n");
19              }
20              else
21              {
22                      printf("File created\n");
23                      fclose(filept);
24              }
25      /* Opening a file, writing a character and closing it */
26              filept = fopen("test.txt","w");
27              fputc(a, filept);
28              fclose(filept);
29
30      /* Open file in append mode, dynamically allocating array, taking string input from user
31      writing it to file and losing it */
32              filept = fopen("test.txt","a");
33              input_string = (char *)malloc(20);
34              printf("Input a string to add to file:");
extended-r Thread 196.196 In: main                                    L23   PC: 0x10798
17      in /home/nachiket/AESD/HW3/track_calls.c
(gdb)
```

```
Listening on port 10000
Remote debugging from host 10.201.62.76
Process /trackcalls created; pid = 252
Its a sunny day outside
File created
Input a string to add to file:nachiket

Value of a = n
Character is: n
String is: nachiket

Child exited with status 0
```

```
nachiket@nachiket-VirtualBox:~/AESD/HW3$ gdb-multiarch -x gdbinit
GNU gdb (Ubuntu 8.1-0ubuntu3) 8.1.0.20180409-git
Copyright (C) 2018 Free Software Foundation, Inc.
License GPLv3+: GNU GPL version 3 or later <http://gnu.org/licenses/gpl.html>
This is free software: you are free to change and redistribute it.
There is NO WARRANTY, to the extent permitted by law.  Type "show copying"
and "show warranty" for details.
This GDB was configured as "x86_64-linux-gnu".
Type "show configuration" for configuration details.
For bug reporting instructions, please see:
<http://www.gnu.org/software/gdb/bugs/>.
Find the GDB manual and other documentation resources online at:
<http://www.gnu.org/software/gdb/documentation/>.
For help, type "help".
Type "apropos word" to search for commands related to "word".
No symbol table is loaded.  Use the "file" command.
Make breakpoint pending on future shared library load? (y or [n]) [answered N; i
nput not from terminal]
No executable file now.
warning: Could not load vsyscall page because no executable was specified
[Inferior 1 (process 252) exited normally]
gdbinit:7: Error in sourced command file:
The program is not being run.
(gdb)
```

Problem 3

Modinfo of kernel module:

```
nachiket@nachiket-VirtualBox:~/AESD/HW3$ modinfo first_kernel_module.ko
filename:       /home/nachiket/AESD/HW3/first_kernel_module.ko
description:    First module
author:         Nachiket
license:        GPL
srcversion:     5296F475E2E206F973B59E5
depends:
retpoline:      Y
name:           first_kernel_module
vermagic:       4.15.0-45-generic SMP mod_unload
parm:           name:Enter your name (charp)
parm:           period:Enter period in milliseconds (ulong)
```

```
Welcome to Nachiket Linux System
Nachiket login: root
Password:
# cd /
# ls
bin                     linuxrc                 sorting
dev                     lost+found              sys
etc                     media                   tmp
first_kernel_module.ko  mnt                     track_calls
first_kernel_module.o   opt                     track_calls.c
helloworld              proc                    usr
helloworld.c            root                    var
lib                     run
lib32                   sbin
# insmod first_kernel_module.ko name="Nachiket" period=5000
```

```
[  330.159237] Your name Nachiket and Timer was fired 4 number of times
[  335.199225] Your name Nachiket and Timer was fired 5 number of times
[  340.239229] Your name Nachiket and Timer was fired 6 number of times
[  345.279233] Your name Nachiket and Timer was fired 7 number of times
[  350.319228] Your name Nachiket and Timer was fired 8 number of times
[  355.359224] Your name Nachiket and Timer was fired 9 number of times
[  360.399233] Your name Nachiket and Timer was fired 10 number of times
[  365.439228] Your name Nachiket and Timer was fired 11 number of times
[  370.479230] Your name Nachiket and Timer was fired 12 number of times
[  375.519227] Your name Nachiket and Timer was fired 13 number of times
[  380.559230] Your name Nachiket and Timer was fired 14 number of times
[  385.599222] Your name Nachiket and Timer was fired 15 number of times
[  390.639219] Your name Nachiket and Timer was fired 16 number of times
[  395.679227] Your name Nachiket and Timer was fired 17 number of times
[  400.719222] Your name Nachiket and Timer was fired 18 number of times
```

With one parameter

```
# insmod first_kernel_module.ko name="Nachiket"
# dmesg
[    0.000000] Booting Linux on physical CPU 0x0
[    0.000000] Linux version 4.14.40 (root@nachiket-VirtualBox) (gcc version 8.2.0 (Bui
```

```
[  453.694894] Module inserted successfully
[  454.202526] Your name Nachiket and Timer was fired 1 number of times
[  454.712047] Your name Nachiket and Timer was fired 2 number of times
[  455.222052] Your name Nachiket and Timer was fired 3 number of times
[  455.732048] Your name Nachiket and Timer was fired 4 number of times
[  456.242057] Your name Nachiket and Timer was fired 5 number of times
[  456.752058] Your name Nachiket and Timer was fired 6 number of times
[  457.262059] Your name Nachiket and Timer was fired 7 number of times
[  457.772055] Your name Nachiket and Timer was fired 8 number of times
[  458.282057] Your name Nachiket and Timer was fired 9 number of times
[  458.792054] Your name Nachiket and Timer was fired 10 number of times
[  459.302060] Your name Nachiket and Timer was fired 11 number of times
#
```

Problem 4:

The data structure used for each set is linked list.

The entries in the seed array is horse,dog,cat,dog,horse,tiger,lion,dog,elk,cat

Using no filter and only passing the elements animals to the array.

```
nachiket@nachiket-VirtualBox:~$ ssh root@128.138.189.209
root@128.138.189.209's password:
# cd /
# insmod list_sort.ko animals=horse,dog,cat,dog,horse,tiger,lion,dog,elk,cat
# dmesg
```

```
# rmmod list_sort.ko
#
```

```
[  505.366070] The ecosystem is ready
[  505.370259] animal_type = cat and count = 2
[  505.373966] animal_type = dog and count = 3
[  505.378334] animal_type = elk and count = 1
[  505.382748] animal_type = horse and count = 2
[  505.387116] animal_type = lion and count = 1
[  505.391707] animal_type = tiger and count = 1
[  505.396170] Number of nodes is 6
[  505.400723] Amount of memory dynamically allocated = 96 bytes
[  505.404127] After filtering the data
[  505.410122] Filter criteria is animal type = none and count = 0
[  505.413891] animal_type = cat and count = 2
[  505.420070] animal_type = dog and count = 3
[  505.424478] animal_type = elk and count = 1
[  505.428848] animal_type = horse and count = 2
[  505.433251] animal_type = lion and count = 1
[  505.437793] animal_type = tiger and count = 1
[  505.442289] Number of filtered animals is 6
[  505.446832] Amount of memory dynamically allocated = 96 bytes
[  505.451238]
[  508.747374] Memory is free for first list
[  508.747401] Amount of memory freed = 96 bytes
[  508.751925] Memory is free for second list
[  508.756481] Amount of memory freed = 96 bytes
[  508.760863] Module removed successfully
[  508.765646]
#
```

Using count filter and only passing the elements animals to the array.

```
# insmod list_sort.ko animal_count_filter=2 animals=horse,dog,cat,dog,horse,tiger,lion,dog,elk,ca
t
# rm list_sort.ko S
```

```
[  673.671736] The ecosystem is ready
[  673.675928] animal_type = cat and count = 2
[  673.679482] animal_type = dog and count = 3
[  673.683930] animal_type = elk and count = 1
[  673.688296] animal_type = horse and count = 2
[  673.692720] animal_type = lion and count = 1
[  673.697279] animal_type = tiger and count = 1
[  673.701785] Number of nodes is 6
[  673.706330] Amount of memory dynamically allocated = 96 bytes
[  673.709956] After filtering the data
[  673.716026] Filter criteria is animal type = none and count = 2
[  673.719761] animal_type = dog and count = 3
[  673.725983] Number of filtered animals is 1
[  673.730353] Amount of memory dynamically allocated = 16 bytes
[  673.734760]
[  738.209141] Memory is free for first list
[  738.209169] Amount of memory freed = 96 bytes
[  738.213632] Memory is free for second list
[  738.218186] Amount of memory freed = 16 bytes
[  738.222561] Module removed successfully
[  738.227116]
#
```

Using animal type filter and only passing the elements animals to the array.

```
# insmod list_sort.ko animal_type_filter="cat" animals=horse,dog,cat,dog,horse,tiger,lion,dog,elk
,cat
# rmmod list_sort.ko
```

```
[  897.474601] The ecosystem is ready
[  897.479049] animal_type = cat and count = 2
[  897.482722] animal_type = dog and count = 3
[  897.487111] animal_type = elk and count = 1
[  897.491547] animal_type = horse and count = 2
[  897.495936] animal_type = lion and count = 1
[  897.500504] animal_type = tiger and count = 1
[  897.505023] Number of nodes is 6
[  897.509593] Amount of memory dynamically allocated = 96 bytes
[  897.513018] After filtering the data
[  897.519045] Filter criteria is animal type = cat and count = 0
[  897.522834] animal_type = cat and count = 2
[  897.528950] Number of filtered animals is 1
[  897.533376] Amount of memory dynamically allocated = 16 bytes
[  897.537762]
```

Using count and animal type filter and only passing the elements animals to the array.

```
# insmod list_sort.ko animal_type_filter="dog" animal_count_filter=2 animals=horse,dog,cat,dog,ho
rse,tiger,lion,dog,elk,cat
# rmmod list_sort.ko
```

```
[ 1333.509218] The ecosystem is ready
[ 1333.513512] animal_type = cat and count = 2
[ 1333.517072] animal_type = dog and count = 3
[ 1333.521453] animal_type = elk and count = 1
[ 1333.525877] animal_type = horse and count = 2
[ 1333.530257] animal_type = lion and count = 1
[ 1333.534908] animal_type = tiger and count = 1
[ 1333.539366] Number of nodes is 6
[ 1333.544386] Amount of memory dynamically allocated = 96 bytes
[ 1333.547761] After filtering the data
[ 1333.553820] Filter criteria is animal type = dog and count = 2
[ 1333.557557] animal_type = dog and count = 3
[ 1333.563689] Number of filtered animals is 1
[ 1333.568058] Amount of memory dynamically allocated = 16 bytes
[ 1333.572463]
[ 1360.910061] Memory is free for first list
[ 1360.910090] Amount of memory freed = 96 bytes
[ 1360.914578] Memory is free for second list
[ 1360.919377] Amount of memory freed = 16 bytes
[ 1360.923655] Module removed successfully
[ 1360.928286]
#
```