CS5250

Assignment 3

Zhang Shuhao
A0120258N

Question 1:

a. When will **`module_init`** and **`module_exit`** be loading/called?
``**lsmod** ($module).ko" will load the module named ($module), and subsequently, **module_init** will be called.
Correspondingly, ``**rmmod**" will unload it, and **module_exit** will be called.

b. What is the command of building the module, installing the module and removing the module?
I write a makefile to support those functions. Specifically, they are implemented as follows.

1. To build the module:

```
TARGET_MODULE:=hello_world_mod
obj-m += $(TARGET_MODULE).o
all:
	make -C /lib/modules/$(shell uname -r)/build M=$(PWD) modules
clean:
	make -C /lib/modules/$(shell uname -r)/build M=$(PWD) clean
```

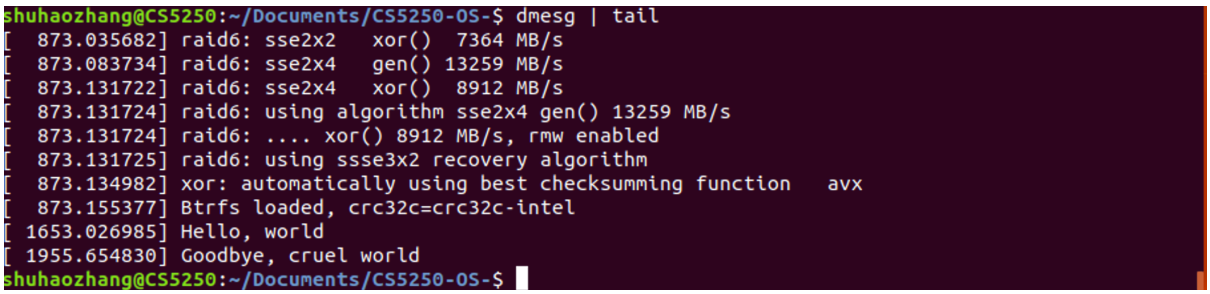
2. To install the module:

```
load:
	insmod ./$(TARGET_MODULE).ko
```

3. To remove the module

```
unload:
	rmmod ./$(TARGET_MODULE).ko
```

c. Give the screenshot of the previous three commands and their results if any in the shell.
The following is the screenshot of ``**dmesg | tail**" after calling ``**lsmod**" and ``**rmmod**" of the hello world module.



d. Add a `<who>` parameter to your module so that your module will show `hello <who>` during init stage.

1. Parameters are declared with the module_param macro, which is defined in moduleparam.h. I highlight the changes in red as follows.

```
#include <linux/kernel.h>
#include <linux/init.h>
#include <linux/module.h>
#include <linux/moduleparam.h> //for module_param
MODULE_LICENSE("GPL");

static char *who = "world";
module_param(who, charp, S_IRUSR|S_IWUSR);
MODULE_PARM_DESC(who, "Tell me your name.");

static int hello_init(void) {
   printk(KERN_ALERT "Hello, %s!\n", who);
   return 0;
}
static void hello_exit(void) {
   printk(KERN_ALERT "Goodbye, %s\n",who);
}

module_init(hello_init);
module_exit(hello_exit);
```

2. lsmod call needs to be updated as well.

```
insmod ./$(TARGET_MODULE).ko who=$(who)
```

I test it with “sudo make load who=``SHUHAOZHANG”, “sudo make unload”. I clean dmesg first by **dmesg –c**
The following screens shot shows the results of **dmesg**.

```
root@CS5250:/home/shuhaozhang/Documents/CS5250-OS-# sudo make load who="SHUHAOZHANG"
insmod ./hello_world_mod.ko who=SHUHAOZHANG
root@CS5250:/home/shuhaozhang/Documents/CS5250-OS-# dmesg
[ 3675.906754] Hello, SHUHAOZHANG!
root@CS5250:/home/shuhaozhang/Documents/CS5250-OS-# make unload
rmmod ./hello_world_mod.ko
root@CS5250:/home/shuhaozhang/Documents/CS5250-OS-# dmesg
[ 3675.906754] Hello, SHUHAOZHANG!
[ 3684.171161] Goodbye, SHUHAOZHANG!
root@CS5250:/home/shuhaozhang/Documents/CS5250-OS-#
```

Question 2:

a. Give the mknod command you use.

``sudo mknod /dev/chardev c **245** 0". Note that, I use dynamic assigning major version instead of fixing at 61, which avoids potential conflict with other device drivers.

b. Give the screenshot of your device with "`ls -l /dev`" command and highlight your device.

```
shuhaozhang@CS5250:~/Documents/CS5250-OS-$ ls -l /dev
total 0
crw-------  1 root        root     10, 235 Apr  4 20:01 autofs
drwxr-xr-x  2 root        root         280 Apr  4 20:01 block
drwxr-xr-x  2 root        root         100 Apr  4 20:01 bsg
crw-------  1 root        root     10, 234 Apr  4 20:01 btrfs-control
drwxr-xr-x  3 root        root          60 Apr  4 20:01 bus
lrwxrwxrwx  1 root        root           3 Apr  4 20:01 cdrw -> sr0
crw-r--r--  1 root        root    245,   0 Apr  4 20:04 chardev
crw-------  1 root        root      5,   1 Apr  4 20:01 console
lrwxrwxrwx  1 root        root          11 Apr  4 20:01 core -> /proc/kcore
crw-------  1 root        root     10,  59 Apr  4 20:01 cpu_dma_latency
crw-------  1 root        root     10, 203 Apr  4 20:01 cuse
drwxr-xr-x  7 root        root         140 Apr  4 20:01 disk
lrwxrwxrwx  1 root        root           3 Apr  4 20:01 dvd -> sr0
lrwxrwxrwx  1 root        root           3 Apr  4 20:01 dvdrw -> sr0
crw-------  1 root        root     10,  61 Apr  4 20:01 ecryptfs
crw-rw----  1 root        video    29,   0 Apr  4 20:01 fb0
lrwxrwxrwx  1 root        root          13 Apr  4 20:01 fd -> /proc/self/fd
crw-rw-rw-  1 root        root      1,   7 Apr  4 20:01 full
crw-rw-rw-  1 root        root     10, 229 Apr  4 20:01 fuse
crw-------  1 root        root    254,   0 Apr  4 20:01 gpiochip0
```

c. Give the codes of read and write functions that you implemented and the screenshots of the four testing cases.

READ:

```
ssize_t onebyte_read(struct file *filep, char *buf, size_t count, loff_t *f_pos)
{
/*please complete the function on your own*/
      int bytes_read = 0;

      /* Check if the buffer has been written */
      if(*buf != 0){
        return 0;
      }
      copy_to_user(buf, onebyte_data, sizeof(char));
      bytes_read ++;
      return bytes_read;
}
```

WRITE:

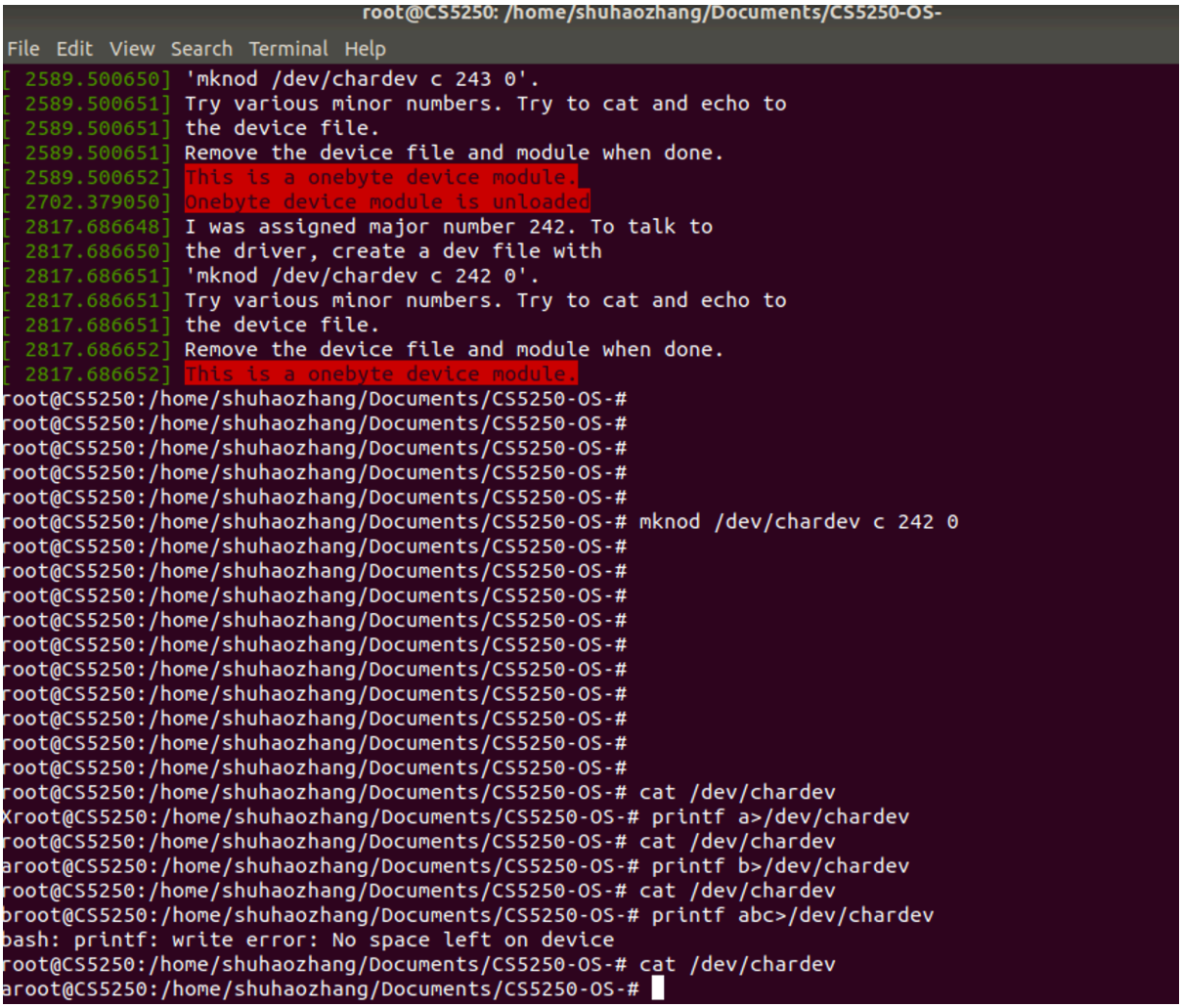
```
ssize_t onebyte_write(struct file *filep, const char *buf, size_t count, loff_t *f_pos)
{
/*please complete the function on your own*/

/**
 * copy_from_user: Returns number of bytes that could not be copied. On success, this will be zero.
 *
 * to
 * Destination address, in kernel space.
 *
 * from
 * Source address, in user space.
 *
```

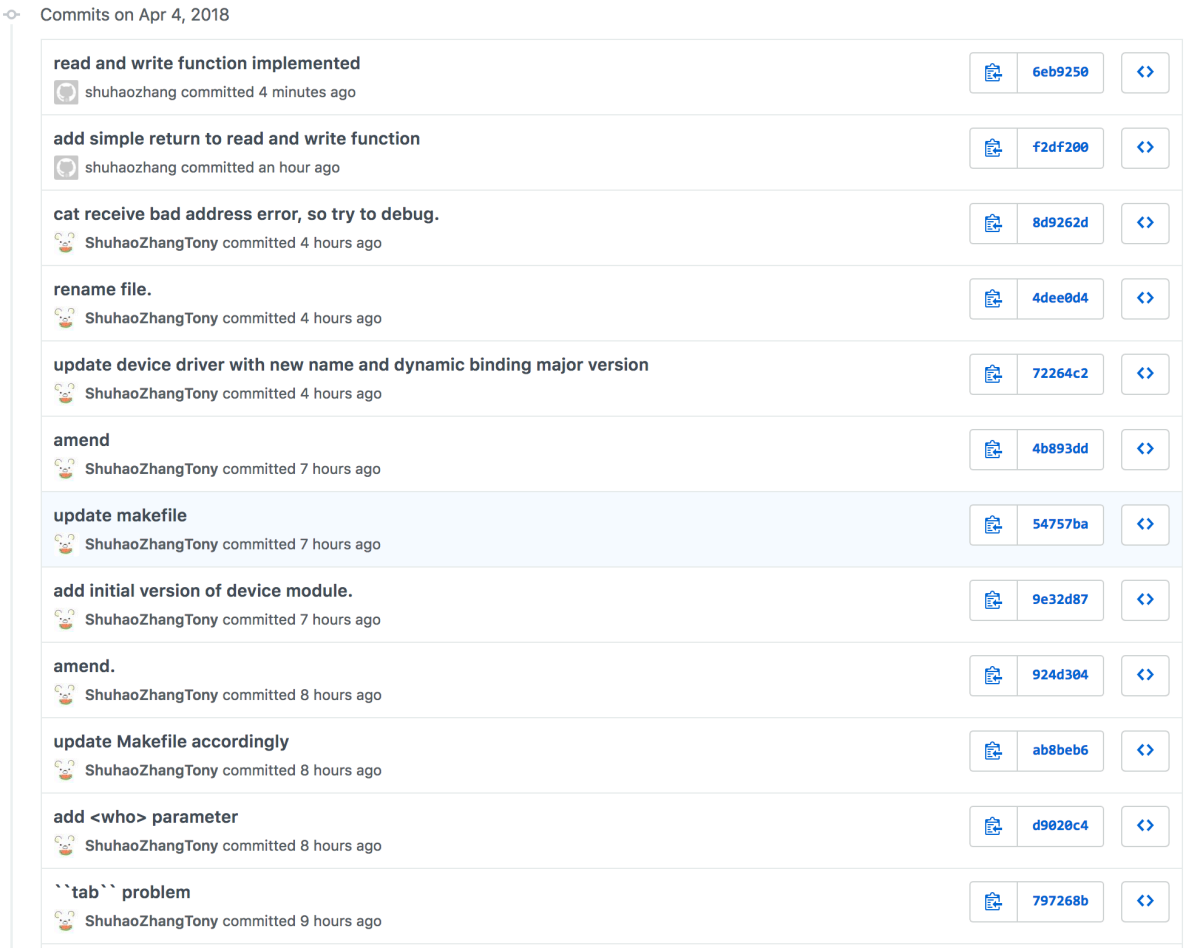
```
* Number of bytes to copy.
*/
    int bytes_write=0;
    copy_from_user(onebyte_data, buf, sizeof(char));

    /* Check the length of the bytes that cannot be written*/
    if(count> sizeof(char))
    {
            printk(KERN_ALERT "No space left on device\n");
            /*Return Linux System Error<28>: No space left on device */
            return -ENOSPC;
    }
    bytes_write++;
    return bytes_write;

}
```



The following is the screenshot of github commit. The last two commit is made inside the virtual machine.



APPENDIX

The following are the source code I used in this project, I have highlighted the changes or important code lines in red.

Chardev.c

```
#include <linux/module.h>
#include <linux/kernel.h>
#include <linux/init.h>
#include <linux/slab.h>
#include <linux/errno.h>
#include <linux/types.h>
#include <linux/fs.h>
#include <linux/proc_fs.h>
#include <asm/uaccess.h>
#include <linux/uaccess.h>
#define MAJOR_NUMBER 61/* forward declaration */

static int Major;                /* Major number assigned to our device driver */
#define DEVICE_NAME "chardev"      /* Dev name as it appears in /proc/devices   */
```

```
int onebyte_open(struct inode *inode, struct file *filep);
int onebyte_release(struct inode *inode, struct file *filep);
ssize_t onebyte_read(struct file *filep,
      char *buf, size_t count,
      loff_t *f_pos);

ssize_t onebyte_write(struct file *filep,
      const char *buf, size_t count,
      loff_t *f_pos);

static void onebyte_exit(void);
/* definition of file_operation structure */
struct file_operations onebyte_fops = {
   read: onebyte_read,
   write: onebyte_write,
   open: onebyte_open,
   release: onebyte_release
};
char *onebyte_data = NULL;

/*
 * Called when a process tries to open the device file, like
 * "cat /dev/mycharfile"
 */
int onebyte_open(struct inode *inode, struct file *filep)
{
        return 0; // always successful
}
int onebyte_release(struct inode *inode, struct file *filep)
{
        return 0; // always successful
}
ssize_t onebyte_read(struct file *filep, char *buf, size_t count, loff_t *f_pos)
{
/*please complete the function on your own*/
        int bytes_read = 0;

        /* Check if the buffer has been written */
        if(*buf != 0){
          return 0;
        }
        copy_to_user(buf, onebyte_data, sizeof(char));
        bytes_read ++;
        return bytes_read;
}
ssize_t onebyte_write(struct file *filep, const char *buf, size_t count, loff_t *f_pos)
```

```
{
/*please complete the function on your own*/

/**
 * copy_from_user: Returns number of bytes that could not be copied. On success, this will
be zero.
 *
 * to
 * Destination address, in kernel space.
 *
 * from
 * Source address, in user space.
 *
 * n
 * Number of bytes to copy.
 */
        int bytes_write=0;
        copy_from_user(onebyte_data, buf, sizeof(char));

        /* Check the length of the bytes that cannot be written*/
        if(count> sizeof(char))
        {
                printk(KERN_ALERT "No space left on device\n");
                /*Return Linux System Error<28>: No space left on device */
                return -ENOSPC;
        }
        bytes_write++;
        return bytes_write;

}
static int onebyte_init(void)
{
//    int result;
   // register the device
   Major = register_chrdev(0, DEVICE_NAME, &onebyte_fops);
   if (Major < 0) {
     printk(KERN_ALERT "Registering char device failed with %d\n", Major);
     return Major;
   }
        printk(KERN_INFO "I was assigned major number %d. To talk to\n", Major);
        printk(KERN_INFO "the driver, create a dev file with\n");
        printk(KERN_INFO "'mknod /dev/%s c %d 0'.\n", DEVICE_NAME, Major);
        printk(KERN_INFO "Try various minor numbers. Try to cat and echo to\n");
        printk(KERN_INFO "the device file.\n");
        printk(KERN_INFO "Remove the device file and module when done.\n");

   // allocate one byte of memory for storage
```

```
   // kmalloc is just like malloc, the second parameter is// the type of memory to be
allocated.
   // To release the memory allocated by kmalloc, use kfree.
   onebyte_data = kmalloc(sizeof(char), GFP_KERNEL);
   if (!onebyte_data) {
      onebyte_exit();
      // cannot allocate memory
      // return no memory error, negative signify a failure
      return -ENOMEM;
   }
//    // initialize the value to be X
   *onebyte_data = 'X';
   printk(KERN_ALERT "This is a onebyte device module.\n");
   return 0;
}
static void onebyte_exit(void)
{
   // if the pointer is pointing to something
   if (onebyte_data) {
      // free the memory and assign the pointer to NULL
      kfree(onebyte_data);
      onebyte_data = NULL;
   }
   // unregister the device
   unregister_chrdev(MAJOR_NUMBER, DEVICE_NAME);
   printk(KERN_ALERT "Onebyte device module is unloaded\n");
}
MODULE_LICENSE("GPL");
module_init(onebyte_init);
module_exit(onebyte_exit);
```

Makefile

```
TARGET_MODULE:=chardev
obj-m += $(TARGET_MODULE).o
all:
	make -C /lib/modules/$(shell uname -r)/build M=$(PWD) modules
clean:
	make -C /lib/modules/$(shell uname -r)/build M=$(PWD) clean
load:
	insmod ./$(TARGET_MODULE).ko
unload:
	rmmod ./$(TARGET_MODULE).ko
```

Hello_world_mod

```
#include <linux/kernel.h>
```

```
#include <linux/init.h>
#include <linux/module.h>

#include <linux/moduleparam.h> //for module_param
MODULE_LICENSE("GPL");

static char *who = "world";
module_param(who, charp, S_IRUSR|S_IWUSR);
MODULE_PARM_DESC(who, "Tell me your name.");

static int hello_init(void)
{
printk(KERN_ALERT "Hello, %s!\n", who);
return 0;
}
static void hello_exit(void)
{
printk(KERN_ALERT "Goodbye, %s!\n", who);
}
module_init(hello_init);
module_exit(hello_exit);
```

Makefile

```
TARGET_MODULE:= hello_world_mod
obj-m += $(TARGET_MODULE).o
all:
	make -C /lib/modules/$(shell uname -r)/build M=$(PWD) modules
clean:
	make -C /lib/modules/$(shell uname -r)/build M=$(PWD) clean
load:
	insmod ./$(TARGET_MODULE).ko who=($who)
unload:
	rmmod ./$(TARGET_MODULE).ko
```